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Under The Hood: Revealing Patterns Of Motor Vehicle Fatalities In The United States

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Abstract

Over the past Century, the car has become an integral part of American society. While automobiles allowed people to travel with unprecedented mobility and independence, they also became a major source of health hazard. Despite large declines in recent decades, motor vehicle deaths still remain significant and are understudied in the discipline of demography. This dissertation looks "under the hood" to reveal and explain patterns of motor vehicle fatalities at the population-level. In the first chapter, I examine why higher unemployment rate is associated with lower motor vehicle death rate. Using state-level data from 2003 to 2013, I find that fatal crashes involving large trucks explain the strong fluctuations between macroeconomic conditions and motor vehicle deaths. Chapter 2 describes the historical changes in the black-white differentials in motor vehicle fatalities. I find that changes in tripmaking rates, risk of death, and socioeconomic status between blacks and whites all play a role in explaining this differential. In chapter 3, I delve further into the current black-white differentials in motor vehicle fatality rates and quantify the extent to which travel amount and risk of death account for these differences. The results show that blacks experience higher motor vehicle fatality rates compared to whites because they are at higher risk of dying when they travel despite travelling fewer miles than whites.

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UNDER THE HOOD: REVEALING PATTERNS OF MOTOR VEHICLE

FATALITIES IN THE UNITED STATES

Monica Mu King

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ABSTRACT

UNDER THE HOOD: REVEALING PATTERNS OF MOTOR VEHICLE FATALITIES IN THE UNITED STATES

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Over the past Century, the car has become an integral part of American society. While automobiles allowed people to travel with unprecedented mobility and independence, they also became a major source of health hazard. Despite large declines in recent decades, motor vehicle deaths still remain significant and are understudied in the discipline of demography. This dissertation looks "under the hood" to reveal and explain patterns of motor vehicle fatalities at the population-level. In the first chapter, I examine why higher unemployment rate is associated with lower motor vehicle death rate. Using state-level data from 2003 to 2013, I find that fatal crashes involving large trucks explain the strong fluctuations between macroeconomic conditions and motor vehicle deaths. Chapter 2 describes the historical changes in the black-white differentials in motor vehicle fatalities. I find that changes in tripmaking rates, risk of death, and socioeconomic status between blacks and whites all play a role in explaining this differential. In chapter 3, I delve further into the current black-white differentials in motor vehicle fatality rates and quantify the extent to which travel amount and risk of death account for these differences. The results show that blacks experience higher motor vehicle fatality rates

compared to whites because they are at higher risk of dying when they travel despite travelling fewer miles than whites.

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CHAPTER 1

Driving through the Great Recession: Why does motor vehicle fatality decrease when the economy slows down? [1]

Introduction

The relationship between short-term macroeconomic fluctuation and mortality is rather counterintuitive. During economic recessions, when economic activities experience significant declines, job losses are linked to worse individual health outcomes through pathways such as losing health insurance coverage and experiencing greater financial and material hardships (Burgard et al., 2013). Instead, temporary economic downturns are often associated with *lower* than expected mortality at the population level. Previous literature suggests that these observed short-term benefits may occur because individuals on the aggregate have more time to engage in healthy behaviors and less money to spend on alcohol and cigarettes (Burgard et al., 2013; Ruhm, 2000). Consistently, a strong relationship between macroeconomic fluctuation due to motor vehicle deaths has remained persistent through as least the past three decades (Ruhm, 2000, 2015).

Motor vehicle crashes represent a major public health hazard and are the leading cause of death for those aged 5 to 25 in the United States (Centers for Disease Control and Prevention, 2014). An average of 37,850 people have died from motor vehicle crash each year from 2004 to 2012, amounting to one death almost every 14 minutes (author's

[1] A slightly modified version of this chapter is published as: He, Monica M. (2016). "Driving through the Great Recession: Why does motor vehicle fatality decrease when the economy slows down?" Social Science & Medicine 155(Apr): 1-11.

calculation based on FARS). Despite their significance, motor vehicle death rates in the United States actually fell every year since 2006 until its recent uptick in 2012 (NHTSA, 2013). Most dramatically, the number of motor vehicle deaths plummeted 18 percent in just two years from 41,259 deaths in 2007 to 33,808 deaths in 2009 (NHTSA, 2009, 2010). These temporary declines in motor vehicle fatalities coincide with the Great Recession of 2007-2009, the longest economic recession since the Great Depression.

In this paper, I examine the relationship between macroeconomic fluctuations and motor vehicle fatality through exposure and risk factors. I augment previous literature by exploring fatal risk factors relating to large trucks, speeding, and other types of collisions. The findings uncover substantial mechanisms that have not been taken into account in previous studies. More broadly, this study provides more insight into the pro-cyclical relationship for motor vehicle deaths and carries important policy implications to combat rising traffic fatalities during economic expansions.

Background

In an influential paper using panel data models, Ruhm (2000) establishes that all-cause mortality varies pro-cyclically with state unemployment rate in the United States over a 20-year period. To be precise, pro-cyclical mortality means that mortality moves in the same direction as macroeconomic conditions deviate above or below the long-term linear trend. This relationship suggests that mortality temporarily rises during economic expansions (i.e. when unemployment decreases) and falls during economic contractions (i.e. when unemployment increases). Thus, falling and rising mortality in this paper refers to *temporary* higher and lower than expected mortality given that the expectation is a linear trend. As unemployment climbs by one percentage point, Ruhm (2000) predicts a 0.5 percent decrease in total mortality rate. While the magnitude of the effect appears to be small, unemployment often rises by more than one percentage point annually during recessionary periods, thus leading to significant declines in mortality (Bureau of Labor Statistics 2015). Other papers using data from Germany (Neumayer, 2004), Japan (Tapia Granados, 2008), and OECD countries (Gerdtham and Ruhm, 2006) also produce results that mirror Ruhm's (2000) findings.

When researchers decompose this relationship by cause- specific deaths, they find that the pro-cyclicality is largely driven by acute causes of death especially those due to motor vehicle crashes, cardiovascular diseases, and pneumonia (Ruhm, 2000; Tapia Granados, 2008; Gerdtham and Ruhm, 2006). Mortality patterns for acute causes of death respond strongly to short-term macroeconomic change unlike those for causes of death with slower disease progression, such as cancer (Ruhm 2000, 2003). In particular, motor vehicle fatalities in the United States have consistently shown a strong, pro-cyclical relationship. Ruhm (2000) suggests that a one-percentage point increase in unemployment lowers the motor vehicle fatality rate by 3 percent, compared to a 0.5 percent reduction for all-cause mortality. In more recent estimates, Ruhm (2015) finds that the association of a one-percentage point increase in unemployment rate for motor vehicle fatality rate has attenuated to 0.9 percent in 2010, but remains significant. Two recent studies that specifically examine the impact of macroeconomic indicators on motor vehicle fatality also arrive at similar conclusions. Cotti and Tefft (2011) use state-quarter-year panel data models and estimate that motor vehicle fatality rate decreases by 1.63 percent for each percentage point increase in state unemployment rate between 2003 and 2009. In a study of motorcycle fatalities, which account for 14 percent of all traffic deaths, French and Gumus (2014) also find the effect of unemployment rate to be 1.8 for motorcycle mortality over several decades in the United States.

Previous studies examine the association between macroeconomic indicators on motor vehicle fatality by evaluating various exposure and risk factors. Exposure relates to changes in the amount of driving at the population level. During economic downturns, overall traffic volume has been hypothesized to shrink because fewer individuals are commuting to work and less commercial activity is occurring on the road (Burgard et al., 2013; Ruhm, 2000). At the same time, individual consumption patterns might also change as people tend to make fewer leisure trips such as going to restaurants and shopping (Cotti and Tefft, 2011; Burgard et al., 2013). Using vehicle miles travelled (VMT), a widely accepted measure of driving exposure, existing papers provide conflicting evidence on the importance of driving exposure in explaining pro-cyclical trends for motor vehicle deaths. In an earlier study, Wagenaar's (1984) time series analysis did not find VMT to explain the link between macroeconomic fluctuations and motor vehicle mortality rates in Michigan. More recently, Cotti and Tefft (2011) find state personal income per capita, but not state unemployment rate, to be positively associated with VMT per capita between 2003 and 2009 in the United States.

In this literature, studies also direct their attention to the risk of certain types of fatal crashes given a fixed exposure of driving. Most studies focus on drunk driving as a risky behavior that might explain increases in motor vehicle fatalities when the economy improves (Wagenaar and Streff, 1989; Ruhm, 1995, Cotti and Tefft, 2011). During economic downturns, individuals are hypothesized to have less disposable income to spend on detrimental normal goods such as alcohol and cigarettes (Ruhm, 2000). Although others contend that higher unemployment has no effect (Xu, 2013) or might even increase alcohol consumption (Frijters et al., 2013), Cotti and Tefft (2011) recently find unemployment rates to be negatively associated with drunk-driving fatalities at the state level. In the context of the Great Recession, they suggest that alcohol-related driving fatalities account for a significant amount of the decline in motor vehicle fatalities between 2007 and 2009.

The existing literature does not adequately address the link between macroeconomic indicators and motor vehicle fatality. Most importantly, previous literature has insufficiently explored the scope of mechanisms that could help explain cyclical variations in fatal motor vehicle crashes. Alcohol-impaired driving fatalities should be examined in conjunction with other types of potentially risky driving behaviors or crash types. Several other plausible factors have been hypothesized to explain the pro-cyclical nature of motor vehicle fatality but have not yet been empirically tested. First, there may be changes in the composition of vehicles during economic downturns, namely in a decrease in the proportion of commercial trucks. French and Gumus (2014) suggest that fewer commercial vehicles during economic downturns can help improve overall road safety because commercial trucks may pose greater danger than passenger cars. Recent statistics show only four percent of all registered vehicles are large trucks (henceforth defined as having a gross weight over 10,000 lbs), but they are involved in crashes accounting for 12 percent of all fatalities each year (Lyman and Braver, 2003). In another study, Wagenaar (1984) only includes fatalities including passenger cars noting that the economy might have a direct effect on truck traffic. However, the ability to differentiate among these various crash types is essential for policy interventions when the economy improves. Because large trucks are generally tied to commercial and economic activity, they could play an important role in the relationship between macroeconomic fluctuations and motor vehicle fatality rate. Another important risk factor that is missing in this empirical literature is speeding, which is a factor in up to one-third of all fatal motor vehicle crashes (Liu et al., 2005). Cotti and Tefft (2011) suggest that the risk behavior of speeding might increase when the economy improves because of the rising opportunity cost of time. Further, speeding-related fatalities may be tied to drunk driving. A government report find speeding involved in over 40 percent of drunk driving crashes compared to just 14 percent of sober crashes (Liu et al., 2005).

Additionally, no study has examined this specific relationship past the recent U.S. Great Recession, officially dated December 2007 to June 2009 (National Bureau of Economic Research). The large macroeconomic fluctuations over the Great Recession presents an ideal setting for understanding the relationship between macroeconomic change on motor vehicle fatality. Although Cotti and Tefft's (2011) study period stretches through the year 2009, which marks the end of the Recession, macroeconomic conditions had not yet subsided to pre-Recession levels. In fact, unemployment rate remained at 10 percent in late-2009, doubled what it was in late-2007 (Bureau of Labor Statistics, 2015). By 2013, unemployment rate had already reached its peak and fallen for three consecutive years (Bureau of Labor Statistics, 2015).

Objectives

Despite compelling evidence supporting the strong empirical relationship between motor vehicle fatality rates and macroeconomic conditions, few papers have attempted to understand the link between the two. Using panel data methods, I will analyze the rise and fall of motor vehicle fatality in the recent recessionary period in order to answer the following research questions: 1) Has the pro-cyclical relationship between motor vehicle fatality and unemployment persisted through the recent Great Recession? 2) How do exposure and risk factors explain the associations between unemployment and motor vehicle fatality rate?

This paper will first analyze new data after the Great Recession through 2013 to capture recent improvements in macroeconomic conditions. More importantly, I will expand the current understanding of pro-cyclical motor vehicle fatalities by providing a deeper analysis into the specific exposure and risk factors that drive pro-cyclical motor vehicle fatality rates. By disaggregating types of motor vehicle crashes, I provide alternative explanations to better understand the mechanisms linking macroeconomic conditions and motor vehicle fatality. My results will show that the story of pro-cyclical motor vehicle fatality aligns more with an explanation of direct changes in commercial activities on the road and cannot simply be explained by changes in drunk driving fatalities.

Methods

Data and Measures

Combining several government data sources, I produce a panel dataset in order to model the relationship between unemployment and motor vehicle fatality rate. Consistent with past research, the level of analysis in this paper is at the state-level. My sample includes 550 (50x11) state-year observations with 50 U.S. states excluding the District of Columbia from 2003 to 2013.

The main dependent variable is motor vehicle fatality rate per 100,000 people. Motor vehicle death counts come from the Fatal Analysis and Reporting System (FARS) database. Under the umbrella of the National Highway Traffic Safety Administration (NHTSA), FARS is a national census that details every motor vehicle crash which occurs on a public road and results in at least one death within 30 days. The NHTSA compiles state-level documents such as police reports, hospital reports, and registration records for the FARS database and coding of crash type. The American Community Survey and the Decennial Census from the U.S. Census Bureau provide mid-year population estimates used in the denominator to calculate fatality rates.

I also use FARS to identify five different types of motor vehicle crashes and calculate fatality rates for each type. Specifically, I examine crashes involving large trucks, crashes involving a speeding vehicle, crashes involving a drunk driver, crashes involving a single vehicle or multiple vehicles, and crashes in urban areas or rural areas. A few terms need additional clarification. As previously stated, large trucks are defined by the NHTSA as over 10,000 lbs. Figure 1.1 shows examples of trucks that meet the specifications of that definition. Drunk driving is best determined through direct police reports of driver's blood alcohol content. Because a large percentage of driver's BAC is missing in FARS, NHTSA also releases a multiple imputation dataset for imputed BAC values based on other characteristics of the crash (Subramanian, 2002). Consistent with French and Gumus' (2014) definition, I define crashes involving a drunk driver when a driver's blood alcohol content (BAC) is at or above 0.08 g/dL. This group is compared with crashes involving no drunk drivers. In supplementary analysis, I present results for no-alcohol involved crashes where all drivers have a BAC of 0.

I further decompose the dependent variable, motor vehicle fatality rates, into the product of two terms: risk and exposure of motor vehicle crashes. Following Cotti and Tefft's (2011) decomposition, risk is operationalized as motor vehicle deaths divided by million vehicle-miles travelled (VMT) while exposure is defined as million VMT divided by the population. VMT estimates for each state are from the Federal Highway Administration (FHWA). The motivation for the decomposition is to understand whether fluctuations in motor vehicle fatality rates are mainly due to changes in the amount of driving (i.e. exposure) or in the number of deaths given a fixed amount of driving (i.e. risk). An increase in the exposure term can occur if there are more drivers on the road or if the same number of drivers are travelling greater distances. On the other hand, an increase in the risk term suggests higher likelihood of experiencing motor vehicle fatalities given a fixed amount of VMT. These terms are also important for interventions that might target how much versus how dangerously people are driving.

Unemployment rate is the main explanatory variable and serves as a proxy for macroeconomic conditions in previous studies (Ruhm, 2000; French and Gumus, 2014; Cotti and Tefft, 2011). Data on unemployment rates are obtained from the United States Bureau of Labor Statistics.

Moreover, I account for a host of state- and year-specific policy controls that have been shown to affect motor vehicle fatalities (Dee et al., 2005; Ferdinand et al., 2015). In line with previous research, I include beer tax and gasoline prices in 2013 dollars (Cotti and Tefft, 2011; French and Gumus, 2014; Grabowski and Morrisey, 2004; Morrisey and Grabowski, 2011). On the policy side, I include the following driving-related laws: bans on handheld devices, bans on texting and driving, primary enforcement of seatbelt laws, 0.08 legal BAC limit, and presence of graduated driver licensing (GDL) program for teenage drivers. The policy controls are coded as dummy variables for the years with the laws enacted. If a law becomes effective in the during the calendar year, I use a fractional value for the year as others have done in similar analysis. (Dee et al., 2005). Appendix

1.**1** Definitions and Sources for Control VariablesAppendix 1.1 summarizes the definitions and sources for each of the control variables.

Analytical Strategy

In the results, I will first show descriptive trends of the main independent and dependent variables. I will then illustrate detrended, bivariate relationships for unemployment and the five types of motor vehicle crashes.

Following the descriptive analysis, I will estimate regression models using Ruhm's (2000) baseline model in Equation 1.1:

$$H_{jt} = \gamma E_{jt} + \beta X_{jt} + S_j + \alpha_t + \varepsilon_{jt}$$

(Eq.1.1)

The outcome, H, is the natural logged motor vehicle fatality rate for state j at year t. E is unemployment rate, the macroeconomic indicator. X is a set of tax and policy controls at the state-year level. The equation also includes national year effects with year dummy variables and state fixed effects. Time effects capture national level time trends, such as improvements in car safety, which might also influence the outcome variable (Muazzam and Nasrullah, 2011). State fixed effects eliminate possible endogeneity from time invariant state characteristics. Finally, the equation includes an error term and robust standard errors.

First, I run the regression with the outcome, H, as total motor vehicle fatality rate to determine the magnitude of the pro-cyclical relationship during the study period. I also test whether using age-standardized fatality rates as the outcome would change the magnitude of the relationship since motor vehicle fatality rates are not constant across ages and the population composition changes over time. After standardizing fatality rates to the 2010 U.S. age distribution with five-year age groups, I find the coefficients to be almost identical. Thus, all analysis in the paper uses the crude fatality rates.

In the next set of regressions, I decompose total motor vehicle fatality rate into risk (i.e. fatalities per million VMT) and exposure (i.e. million VMT per 100,000 people). Equation 1.2 shows that with the outcome logged, motor vehicle fatality rate can be decomposed into the sum of logged risk and logged exposure. As shown in Cotti and Tefft's (2011), this decomposition allows me to conduct two separate regression analysis with each component set as the outcome. Again, the purpose of the decomposition is to assess the contribution of each component to the pro-cyclical relationship between unemployment and motor vehicle fatality rates.

$$\ln\left(\frac{\textit{Motor Vehicle Fatality Rate}}{100{,}000\ \textit{people}}\right)=\ln\left(\frac{\textit{Fatalities}}{\textit{VMT}}\right)+\ln\left(\frac{\textit{VMT}}{100{,}000\ \textit{People}}\right)$$

(Eq. 1.2)

Finally, I run regression analysis with the outcome as motor vehicle fatality rate for each of the five types of crashes introduced earlier in the paper and their complements. By disaggregating motor vehicle fatality rates into types of crashes, I examine previously unexplored mechanisms that can provide insight into the pro-cyclicality patterns of motor vehicle deaths.

Results

Descriptive Trends

I first show descriptive trends of the independent and dependent variables during this study period. Figure 1.2a illustrates the large variation in average state unemployment rate between 2003 and 2013. At the onset of the Great Recession in 2007, unemployment rate sits low at just under 4.5 percent on average across states but soon jumped to almost 9 percent at the end of the recession in 2010. In more recent years, unemployment rate on average has experienced a steady decline and is on pace to return to pre-recession levels.

Figure 1.2b shows the trend for total motor vehicle fatality rate during the 11-year study period. Average state motor vehicle fatality rate holds steady at above 16 per 100,000 from 2003 to 2006. In 2007, the average fatality rate drops below 16 per 100,000 and continues to fall until it reaches just below 12 per 100,000 in 2011. After an increase in 2012, average motor vehicle fatality rate falls to the lowest level in 2013. The decline in average motor vehicle fatality rates is 8.4 percent annually during the years of the Great Recession in 2007-2009, which is significantly larger than the declines from 2003-2006. Figure 1.2c and Figure 1.2d compares the trend between the risk and exposure components of the decomposition in Equation 2. The trend in risk (Figure 1.2c) is represented by average state motor vehicle deaths per million VMT while exposure (Figure 1.2d) is the average state million VMT per 100,000 people. Whereas the risk term appears to mimic the fatality rate trend in Figure 1.2c, the exposure component remains relatively flat from 2003 to 2013.

Detrended Relationships

Figure **1.3** illustrates bivariate relationships between unemployment rate and different types of motor vehicle fatality rates from 2003 to 2013. All rates have been detrended and normalized in order to understand associations as rates rise above and below the linear trend measured in standard deviations from the mean rate. Figure 3a clearly shows the pro-cyclicality of all motor vehicle fatality rates – as the economy improves in the first half of the study period (using the proxy of unemployment declining below the trend), motor vehicle fatality rates increase above the trend. I find the pro-cyclical pattern to persist into the second half of the study period.

The rest of the

Figure **1.3** examines complementary pairs of motor vehicle fatality rates with unemployment rate. Moving from

Figure **1**.**3**b to

Figure **1**.**3**f, I compare large truck and non-large truck fatality rates (

Figure **1**.**3**b), speeding and non-speeding fatality rates (

Figure **1**.**3**c), drunk and non-drunk fatality rates (

Figure **1**.**3**d), single and multiple vehicle fatality rates (

Figure **1**.**3**e), and rural and urban fatality rates (

Figure **1**.**3**f). While pro-cyclicality cannot be visually determined alone, several noticeable deviations around the timing of the Great Recession should be mentioned. The graph in

Figure **1**.**3**b shows that fatalities involving large trucks (triangle icon) decline to over two standard deviations below the mean in 2009 compared to less than one standard deviation below the mean for non-large truck fatality rates (square icon). Similarly, in

Figure **1**.**3**f, fatality rates in urban areas (triangle icon) drop to almost two standard deviations below the mean in 2009 compared to rural fatality rates (square icon) which deviate less than one standard deviation below the mean. The patterns for the other pairs, including drunk and non-drunk fatalities, are rather similar, and pro-cyclicality for all the pairs cannot be discerned by the graphs alone. However, fatalities involving large trucks falls sharply toward the end of the Great Recession and could be a significant contributor to the pro-cyclical relationship between unemployment and motor vehicle fatalities.

Regression Analysis

Building on the descriptive graphs, I run multivariate regression analysis to assess the significance of the associations at the state-level. Table 1.1 displays the regression results for the association between state unemployment rate and total state motor vehicle fatality rate. The coefficient in the first model with just state fixed effects and national linear time trend is -0.0282 ($p<0.05$). For each percentage point increase in unemployment rate, motor vehicle fatality decreases by 2.82 percent. With the inclusion of tax and policy controls, the coefficient changes slightly to -0.0288 ($p<0.05$). Results from Table 1.1 suggests that the significant, pro-cyclicality of motor vehicle fatality has persisted in the recent decade and through the Great Recession.

In order to better understand what is driving the pro-cyclical nature of motor vehicle fatalities, I decompose total motor vehicle fatality rate into aforementioned risk and exposure components. As stipulated by Equation 2, the regression coefficient from the risk and exposure components would add up to the coefficient for total fatality rate (-0.0288). Table 1.2 presents this decomposition result with three different models that have the same independent variables but three different outcomes (i.e. total fatality rate, risk component, and exposure component). The interpretation for Table 1.2 is that for each percentage point increase in unemployment, the risk (i.e. fatalities per million VMT) decreases by 2.5 percent ($p<0.05$) compared to a 0.4 percent nonsignificant decrease in the exposure (i.e. a million VMT per 100,000 people). The decomposed coefficients also mean that the risk component accounts for 88 percent (0.0252/0.0288) of the motor vehicle pro-cyclical relationship. This finding is not surprising given the descriptive graph in Figure 1.2d depicts a flat line for the exposure component.

After establishing that the risk, and not exposure, accounts for almost all of the motor vehicle pro-cyclicality, I now examine the relationship between unemployment and various crash types in order to pinpoint specific types of crashes that elevate fatality risk. Table 1.3 presents the regression coefficients for unemployment rate for the five types of crashes and their complements. I only show the main unemployment coefficients in Table 1.3 because only three coefficients for the control variables have significant associations with the outcome. Detailed results with all coefficients are presented in Appendix 1.2 and 1.3. Although adding tax and policy control variables do not change the unemployment coefficients significantly, I direct my attention to the results in the second and fourth column with the full control variables included.

The first row of Table 1.3 compares the cyclical relationship between motor vehicle fatalities involving large trucks and those not involving large trucks. The regression coefficients for large truck fatalities is significant at -0.0837 ($p<0.001$). Each percentage increase in unemployment rate equates to an 8.4 percent decrease in fatalities involving large trucks. In contrast, fatality rates for crashes that do not involve large trucks are not significant (coefficient = -0.0207, NS).

The second row examines fatality rates for crashes involving speeding and those not involving speeding. Results show speeding-related fatalities are significantly pro-cyclical (coefficient = -0.0503, $p<0.05$) while fatalities not involving speeding are not significantly pro-cyclical (coefficient = -0.0201, NS). Each percentage increase in unemployment rate is met with a 5.3 percent decrease in speeding-related motor vehicle fatalities.

Moving onto the next row, I find that both drunk driving and non-drunk driving fatalities are significantly pro-cyclical. When unemployment increases by one percentage point, drunk driving fatality rates are expected to fall 3.6 percent ($p<0.05$) compared to 2.5 percent for non-drunk driving fatality rates ($p<0.05$).

The fourth row compares single-vehicle fatalities and multi-vehicle fatalities. I find multi-vehicle fatality rates to be pro-cyclical whereas single-vehicle fatality rates are a-cyclical. Multi-vehicle fatality rates are expected to decline 4.1 percent ($p<0.05$) as unemployment rate climbs by one percentage point compared to only a 2 percent (NS) decrease for single-vehicle fatality rates.

Finally, the last row shows regression coefficients for rural and urban motor vehicle fatality rates. Fatality rates in urban areas respond more strongly to changes in unemployment. For each percentage point increase in unemployment rate is expected to lower urban fatality rates by 4.6 percent ($p<0.05$) and rural fatality rates by 1.7 percent (NS).

Collectively, the results in Table 1.3 reveal significant pro-cyclical motor vehicle fatality for crashes involving large trucks, crashes involving speeding, multi-vehicle crashes, crashes in urban areas, and both drunk and non-drunk driving crashes. Although past research singularly focuses on drunk driving crashes as an explanation for motor vehicle fluctuations, these results illuminate other types of crashes that sync with the macroeconomic cycle.

Additional Analysis

To rule out the alternative hypothesis that alcohol-related driving is the underlying cause of these other types of fatal crashes, I conduct the same regression analysis with only fatalities involving no alcohol (BAC = 0) to see if the results remain robust. If these other types of crashes are indeed related to drunk driving, then the significant results in Table 1.3 would not hold in the no-alcohol involved sample. Table 1.4 shows the results of this additional analysis for the four types of crashes – those involving large trucks, speeding vehicles, multiple vehicles, and in urban areas. All the regression coefficients remained robust in Table 1.4 except for urban crashes which are no longer significant due to larger standard errors (coefficient = -0.0408, NS). For speeding crashes and multi-vehicle crashes, each percentage point increase in unemployment is associated with a 5.4 and 3.9 percent decrease (both $p<0.05$) in fatality rates, respectively. The same increase in unemployment is expected to decrease no-alcohol related large truck fatality rates by over 10 percent ($p<0.001$).

Discussion and Conclusion

Following up on the objectives of the paper, my results confirm that total motor vehicle fatality has remained strongly pro-cyclical in the recent decade including the years through the Great Recession. For all fatal motor vehicle crashes, each percentage point increase in unemployment rate predicts a significant 2.9 percent decrease in fatality rate. Both the magnitude and the direction of this association is consistent with or even larger than those in past findings (Cotti and Tefft, 2011; French and Gumus, 2014; Ruhm, 2015). I also show that the risk of fatalities per million VMT contributes 88 percent to the magnitude of the pro-cyclical relationship. The significance of the risk component also aligns with previous findings (Cotti and Tefft, 2011). This result suggests that reductions in motor vehicle fatalities during economic downturns cannot be explained by fewer miles driven on average but by reduction in the risk of death per miles driven.

More importantly, the results offer new explanations for why motor vehicle fatality rates fluctuate with changes in unemployment. Previous studies have almost solely focused on drunk driving as the explanation for pro-cyclical motor vehicle fatality (Wagenaar and Streff, 1989; Ruhm, 1995, Cotti and Tefft, 2011). Contradicting Cotti and Tefft's (2011) previous assertion that only drunk driving fatalities are pro-cyclical, I find both drunk-driving and non-drunk driving related crashes to exhibit pro-cyclical patterns. Combined with the significant findings by crash type, I dismantle the existing explanation that changes in drunk driving alone are sufficient to explain the pro-cyclicality of motor vehicle fatalities.

The most compelling finding is that fatalities involving large truck are predicted to drop over 8 percent for each percentage point increase in unemployment rate. Among crashes without alcohol, large truck fatalities are expected to decrease by an astonishing 10 percent for each percentage point rise in unemployment rate. These numbers stand in stark contrast to only a nonsignificant 2 percent decrease in fatalities not involving large trucks given the same change in unemployment rate. Large trucks over 10,000 lbs, as defined in this paper, are most likely tied to commercial uses. French and Gumus (2014) previously raise the (untested) hypothesis that motor vehicle fatalities increase during economic booms because of the changing composition of vehicles on the road. Specifically, more trucks on the road could lead to more dangerous driving conditions and more severe crashes for smaller passenger cars and motorcycles. Figure 1.4 shows the trend for proportion of truck registrations as a proxy for truck composition. Indeed, while proportion of truck registration climbs steadily in the beginning of the study period, it stalled during the Great Recession from 2007 to 2009 before rising again. This trend supports the hypothesis that fatalities involving large trucks increase when the economy improves because of changes in vehicle mix.

The results also reveal significant pro-cyclical relationships between unemployment and crashes involving multiple-vehicles and those in urban areas. A temporary increase in these types of crashes, along with commercial trucks, when the economy improves suggests mechanisms related to congested urban traffic. While the decomposition analysis does not find *number* of miles travelled to vary with the economic cycle, it is possible that the distance travelled remain relatively stable but are *distributed* differently across economic cycles. For instance, cars might be more likely to be travelling at the same time along the same flow of traffic, syncing with a typical commuting schedule. In that case, driving during economic booms can increase drivers' exposure to other cars on the road by driving at the same time, thus elevating their risk of colliding in a multi-vehicle crash. While multi-vehicle crashes remain robust to the analysis of only no-alcohol involved crashes, results for urban crashes are no longer tenable in the same analysis, suggesting that urban fatalities are more likely related to drunk driving. These new findings on the significant pro-cyclicality of multi-vehicle crashes and, to a lesser extent, urban crashes expand our current understanding of mechanisms beyond the drunk driving paradigm.

I also test the hypothesis that speeding-related fatalities increase during temporary economic improvements. Proposed by Cotti and Tefft (2011), the theory is that people are more likely to drive in a hurry when the opportunity cost of time is high. Speeding-related fatalities are indeed significantly pro-cyclical even when I exclude alcohol-related crashes, suggesting that speeding is not only a byproduct of drunk driving behaviors (Liu et al., 2005). Instead, the risk of speeding fatalities is a function of opportunity costs.

This study is not without limitations. First, FARS data is based on aggregated reports, including original police reports at the scene of the crash. The reliability of these reports may come into question with less concrete variables, such as speeding, which are based on eyewitness reports. However, even without witnesses, excessive speeding may be inferred from the severity of the crash. A second limitation lies in operationalizing exposure to motor vehicle crash. Vehicle miles travelled (VMT) only measures exposure by distance and does not capture total time spent driving or exposure to numbers of cars on the road. Another potential problem with VMT is that the average number of passengers in vehicles can vary across time due to changes in carpooling, for example, and thus lead to variations in exposure not captured by VMT. However, data from the U.S. Census Bureau suggests that carpooling rates for commuting purposes have experienced a small and steady decline with no observable differences during the recent recession (McKenzie and Rapino, 2011; McKenzie, 2015). Nevertheless, I include VMT because it is a reliable, nationally reported measure that has been consistently used in previous studies. Future research can explore different exposure factors by taking advantage of transportation time-use data such as those from the National Household Travel Survey. Finally, there is an issue with endogeneity and causality. To alleviate concerns of endogenous variables, I include state fixed effects and national time trends in the regression. Even with fixed effects and a host of state-level controls, I am not able to account for other unobserved, time-varying variables that might correlate with the independent and dependent variables. Moreover, the regression results can only suggest strong associations between macroeconomic change and fatality rates rather than causal relationships. While I cannot rule out reverse causation, it is certainly more plausible for state-level unemployment to cause changes in state-level motor vehicle fatality rates than the reverse direction.

The findings carry important implications for informing policy and future research on reducing motor vehicle fatalities. Implementing policies targeting fatalities involving commercial trucks would be valuable toward the goal of reducing total motor vehicle deaths. Future research should examine whether the fault lies with truck drivers or the other drivers. If drivers of commercial trucks are inadequately trained or overworked, then the point of intervention should start in the trucking industry. On the other hand, perhaps passenger car drivers do not know how to navigate around large trucks. In that case, urban planner and road safety organizations should determine how to improve driving conditions when large and small vehicles share the road. Another direction for future research is to understand how time and space constraints can explain the pro-cyclical patterns of these crashes. Commercial activity on the road may be occurring at the same time each day, creating congested roads that make navigating traffic difficult and unsafe. If these types of fatal crashes take place at certain times, such as during rush hour, policy implications might be to incentivize workers to take public transportation, implement telework programs, or create different routes for commuters and commercial traffic.

The subject of how population-level mortality fluctuates with the economic cycle is of interest to many social scientists. Research on previous recessionary periods suggests that economic downturns may lead to temporary improvements in population health and mortality. But Ruhm's (2015) recent paper asserts that pro-cyclicality of total mortality has waned in the recent cycle because some causes of death, such as cancer and poisoning, have emerged as counter-cyclical. Despite weakening relationships for the overall trend, motor vehicle crash is one of the few causes of death that remains pro-cyclical through recent years (Ruhm 2015). The findings in this paper bolster evidence on the persistent strength of motor vehicle fluctuations across the economic cycle. My findings reveal the important role large truck, multi-vehicle, and speeding crashes play in influencing the pro-cyclical relationship. Collectively, these are risk factors that broadly suggests motor vehicle fatality rates rise during economic booms because of a direct increase in commercial activity and brings to light the potential traffic hazards of work itself. The policy implications should help practitioners and policymakers alike pinpoint specific areas where they could intervene to reduce preventable motor vehicle fatalities in the future.

Table 1.1 Regression Coefficients (SE) for the Relationship between State Unemployment Rate and Total MV Fatality Rate, 2003-2013

	Total MV Fatality Rate	Total MV Fatality Rate
Unemployment Rate	-0.0282*	-0.0288*
	(0.012)	(0.012)
Beer Tax (in 2013 $)		0.0006
		(0.057)
Gas Prices (in 2013 $)		0.1156
		(0.075)
Texting Ban		0.0201
		(0.021)
Handheld Ban		-0.0409
		(0.040)
BAC Limit		-0.0144
		(0.050)
Seat Belt Law		-0.0114
		(0.027)
GDL		0.0158
		(0.022)

Includes state fixed effects and national linear time trend.
* p<0.05, ** p<0.01, *** p<0.001
Source: FARS, NHTSA, 2003-2013

Table 1.2 Decomposing Regression Coefficients (SE) into Risk and Exposure of MV Fatality Rate, 2003-2013

	MV Fatality Rate (Fatalities per 100,000)	Risk Component (Fatalities per Million VMT)	Exposure Component (Million VMT per 100,000)
Unemployment Rate	-0.0288*	-0.0252*	-0.0036
	(0.012)	(0.010)	(0.004)
Beer Tax (in 2013 $)	0.0006	-0.0109	0.0115
	(0.057)	(0.044)	(0.026)
Gas Prices (in 2013 $)	0.1156	0.0396	0.0760*
	(0.075)	(0.082)	(0.035)
Texting Ban	0.0201	0.0155	0.0046
	(0.021)	(0.019)	(0.010)
Handheld Ban	-0.0409	-0.0366	-0.0044
	(0.040)	(0.034)	(0.016)
BAC Limit	-0.0144	-0.0182	0.0038
	(0.050)	(0.047)	(0.013)
Seat Belt Law	-0.0114	-0.0046	-0.0068
	(0.027)	(0.024)	(0.011)
GDL	0.0158	0.0060	0.0099
	(0.022)	(0.021)	(0.010)

Includes state fixed effects and national linear time trend.
* p<0.05, ** p<0.01, *** p<0.001
Source: FARS, NHTSA, 2003-2013

Table 1.3 Regression Coefficients (SE) for the Relationship between State Unemployment Rate and MV Fatality Rates by Crash Type, 2003-2013

No controls	Full controls	No controls	Full controls
Large Trucks	Large Trucks	Non-Large Trucks	Non-Large Trucks
-0.0761***	-0.0837***	-0.0207	-0.0207
(0.021)	(0.021)	(0.011)	(0.011)
Speeding	Speeding	Non-Speeding	Non-Speeding
-0.0449*	-0.0503*	-0.0199	-0.0201
(0.022)	(0.020)	(0.013)	(0.013)
Drunk Driving	Drunk Driving	Non-Drunk Driving	Non-Drunk Driving
-0.0357**	-0.0362*	-0.0255*	-0.0254*
(0.013)	(0.014)	(0.011)	(0.011)
Single-Vehicle	Single-Vehicle	Multi-Vehicle	Multi-Vehicle
-0.0206	-0.0202	-0.0389*	-0.0406*
(0.011)	(0.011)	(0.016)	(0.016)
Rural	Rural	Urban	Urban
-0.0191	-0.0174	-0.0455*	-0.0457*
(0.014)	(0.013)	(0.018)	(0.019)

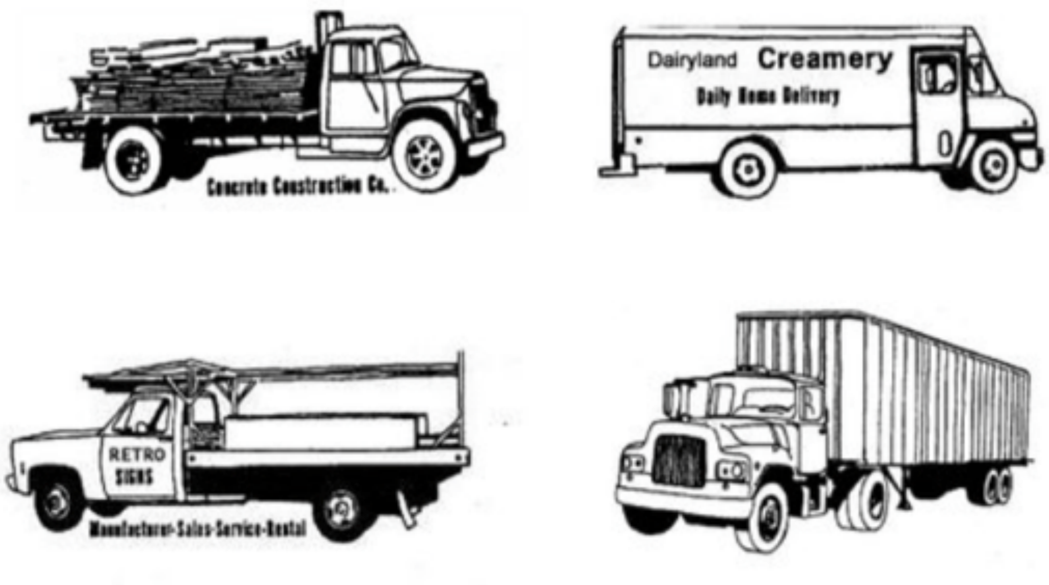
Includes state fixed effects and national linear time trend.
* p<0.05, ** p<0.01, *** p<0.001
Source: FARS, NHTSA, 2003-2013

Table 1.4 Regression Coefficients (SE) for the Relationship between State Unemployment Rate and No-Alcohol Involved MV Fatality Rates, 2003-2013

	Large Trucks	Speeding	Multi-Vehicle	Urban
Unemployment Rate	-0.1038***	-0.0541*	-0.0394*	-0.0408
	(0.023)	(0.024)	(0.017)	(0.022)
Beer Tax (in 2013 $)	0.1439	0.1198	0.1302	0.1151
	(0.140)	(0.186)	(0.087)	(0.130)
Gas Prices (in 2013 $)	0.4671	0.0054	0.3018*	-0.1844
	(0.252)	(0.201)	(0.125)	(0.242)
Texting Ban	0.0328	0.0867	0.0412	0.0589
	(0.062)	(0.080)	(0.043)	(0.060)
Handheld Ban	-0.0407	0.0446	-0.2055**	-0.1065
	(0.070)	(0.151)	(0.063)	(0.056)
BAC Limit	-0.2195	-0.0671	-0.177	-0.3008*
	(0.161)	(0.120)	(0.101)	(0.147)
Seat Belt Law	-0.0296	-0.1109	-0.0096	-0.0584
	(0.072)	(0.074)	(0.043)	(0.063)
GDL	0.0049	0.0046	-0.0319	0.0255
	(0.096)	(0.080)	(0.048)	(0.053)

Includes state fixed effect and national linear time trend
* $p<0.05$, ** $p<0.01$, *** $p<0.001$
Source: FARS, NHTSA, 2003-2013

Figure 1.1 Examples of Trucks over 10,000 lbs



Source: Michigan Automobile Insurance Placement Facility, 2015

Figure 1.2 Descriptive Trends for Main Independent and Dependent Variables, 2003-2013

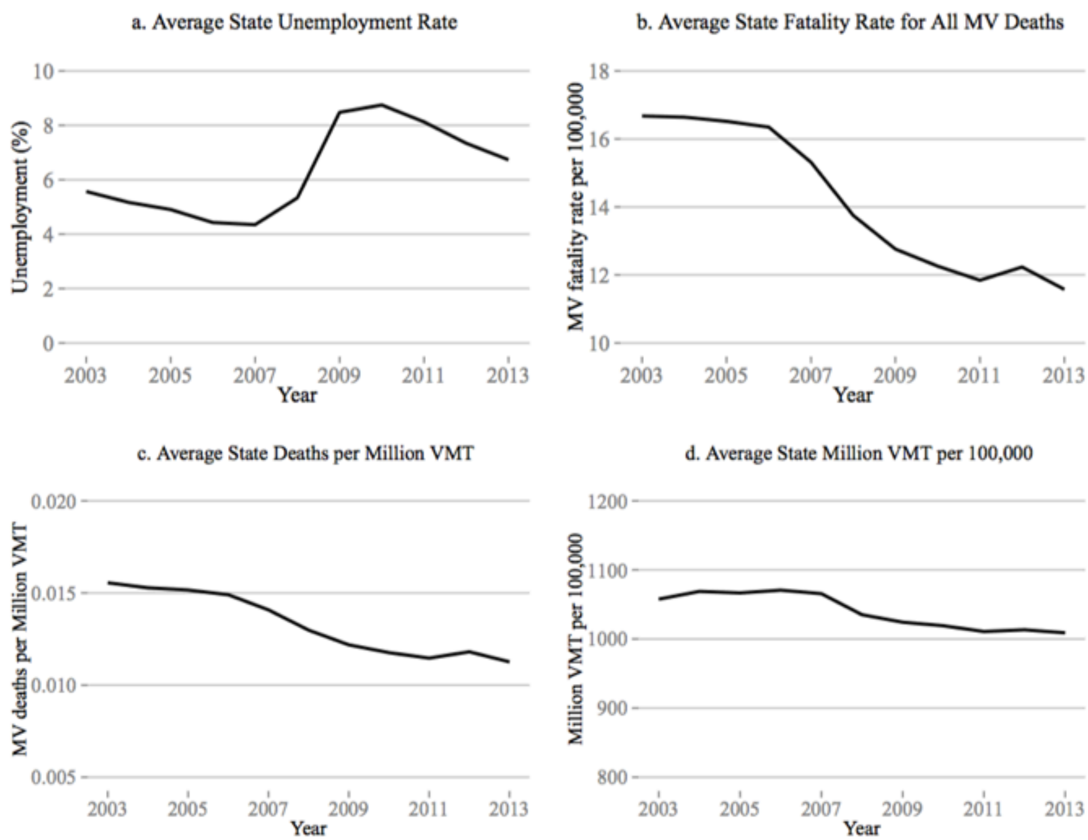


Figure 1.3 Detrended and Normalized Rates for Unemployment and MV Fatalities, 2003-2013

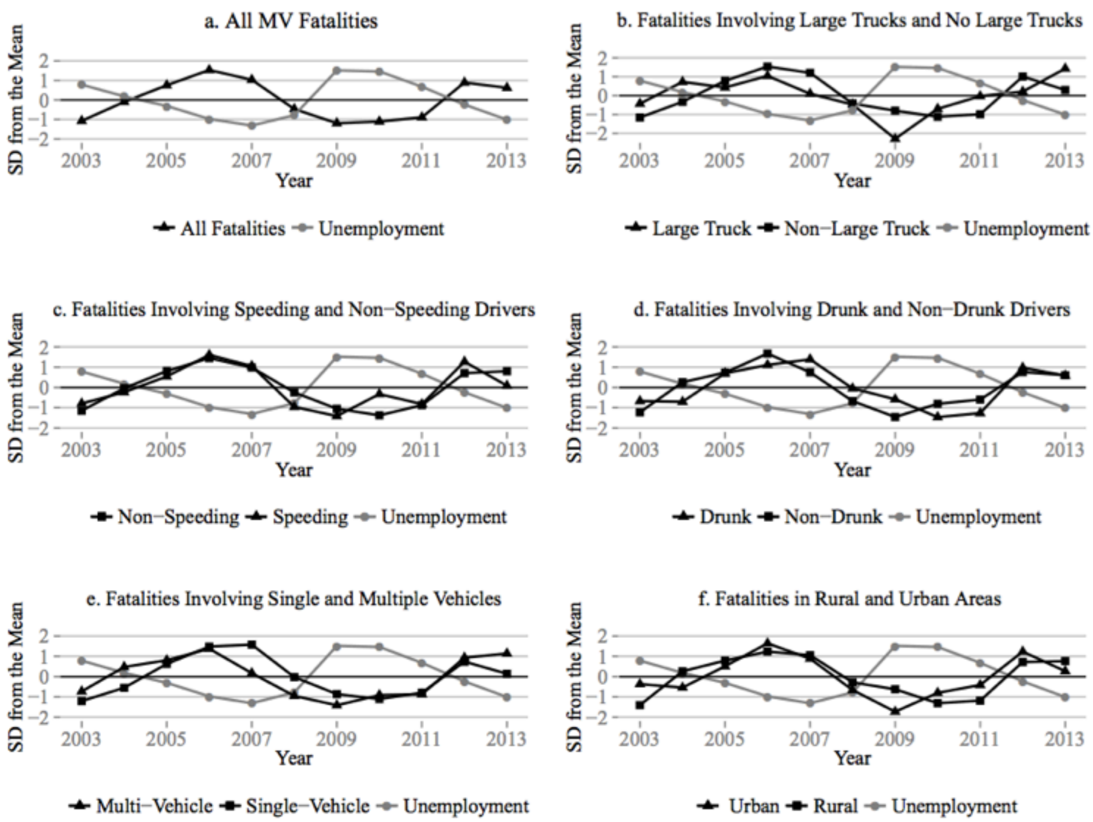
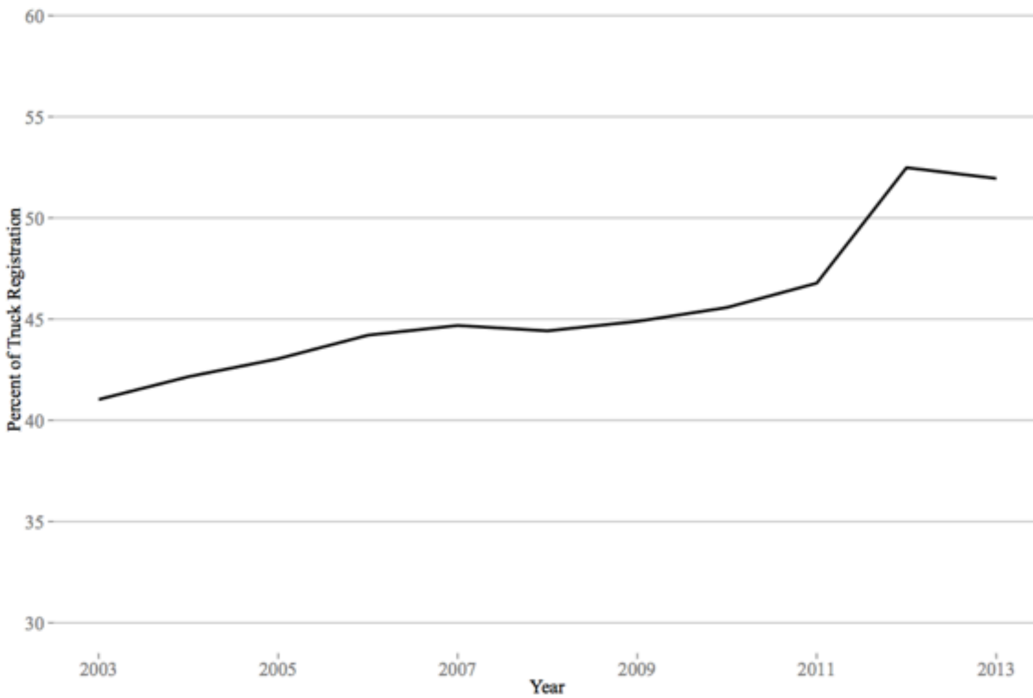


Figure 1.4 Truck Registrations As Percent of All Motor Vehicle Registrations, 2003-2013



CHAPTER 2

Historical Black-White Differentials in Motor Vehicle Fatalities: Examining Factors of Tripmaking, Risk of Death, and Socioeconomic Status.

Introduction

The automobile was introduced at the turn of the 20th Century and has since revolutionized how people move, how the economy functions, and what our neighborhoods look like. By 1920, 2 million cars were sold each year, and the car has since become an integral part of American society (Lemov, 2015). While automobiles allowed people to travel with unprecedented mobility and independence, they also became a significant source of health hazard in the 20th Century. Motor vehicle fatality rates peaked in the late-1930s and again in the late-1960s (Li et al., 2001). Previous literature on the demographic analysis of these deaths has identified important secular changes in the age and sex patterns of motor vehicle deaths, but has not yet explored the racial differences in these outcomes over time (Li et al., 2001; Pampel, 2001). Given the unequal lives of blacks and whites and how much transportation is embedded in our lives, it is possible that these groups experienced different motor vehicle death rates throughout the 20th Century. At the core of this chapter, I wrestle with the tension that blacks — due to their social disadvantage — are likely traveling less than whites, but may be at higher risk of dying of a motor vehicle crash when they travel.

Historically, there is evidence that blacks experienced limited mobility in how they travel, when they travel, and where they travel. Since the post-Civil War era until

1965, Jim Crow laws enforced segregation between blacks and whites, particularly in the South, under the veil of "separate but equal" treatment. Under Jim Crow laws, blacks faced discrimination in public arenas including on public buses where they are only allowed to sit in the back. Under this context, a growing group of middle class blacks found the car as an alternative to avoid discrimination on public modes of transportation, especially as the car became more accessible to middle class blacks (Franz, 2012). However, blacks still faced discrimination driving private automobiles that prevented them from experiencing unfettered mobility. Blacks were often harassed on the road; imposed limitations on where they can drive; and refused service from gas stations, repair shops, and rest stops (Seiler, 2012). In fact, a travel guide geared toward black drivers called *The Negro Motorist Green Book* was published annually from 1936 to 1966 to guide black drivers to stores and service stations that would not discriminate against them (Seiler, 2012). Although limited mobility is not a desirable outcome, it may have been advantageous in shielding blacks from higher exposure to motor vehicle travel, crash, and, sometimes, death.

There is also reason to believe that blacks' social disadvantage has adversely affected their risk of motor vehicle death. One historical example is the effect of interstate highway on the condition of black neighborhoods. As the car enabled more people to travel farther, highways became a solution to accommodate the increasing demand. Significant highway construction took place post-WWII with the Federal Aid Highway Act of 1956, which allocated $25 billion to interstate highway construction over the next two decades (Lewis, 2013). Many scholars argued that highways were hastily planned and built for the convenience of the generally white suburban population to commute to work at the expense of building massive structures in urban, often black, areas (Davies, 1975; Kay, 1997). Highways essentially restructured urban neighborhood, led to de-investment in minority neighborhood infrastructure, and thus possibly provided more dangerous conditions for driving and walking. Moreover, highway construction lowered property values and may have further pushed urban areas into poverty (U.S. Federal Highway Administration, 1976). The deterioration of urban black neighborhoods is one example of how blacks' poorer social conditions may have led to worse motor vehicle death outcomes.

Objectives

The purpose of this chapter is to identify and explain black-white differences in motor vehicle fatalities in the 20th Century with a focus on 1970 to present day trends. In Section 1, I will illustrate the demographic trends in motor vehicle death rates for blacks and whites over time with age-adjusted rates from 1934 and age-specific rates from 1969. To the best of my knowledge, this is the first time descriptive data on black-white differentials in motor vehicle death rates are shown for this entire time frame. As the results will show, these differentials are age-specific, change across time, and raise questions about the mechanisms that drive these differences. In Section 2, I conduct a macro-level analysis using the National Household Travel Survey to examine the trend in travel patterns for blacks and whites from 1977 to 2009 and how these patterns relate to the demographic results presented in Section 1. Specifically, I look at the black-white differentials in trips travelled per population and motor vehicle deaths per trip travelled. In Section 3, I use micro-level data from the National Health Interview Survey with over 20 years of mortality follow-up to evaluate how key measures of socioeconomic status account for the risk of motor vehicle deaths among black adults compared to whites.

Section 1. Demographic trends and Historical Context

I begin by showing the overall levels of age-adjusted motor vehicle death rates for black and whites by sex. The data, described below, was procured from several sources at the Center for Disease Control and Prevention (CDC). Figure 2.1 displays these results in 3-year moving averages from 1934 to 2014.[2] In terms of overall levels, each race-sex group has experienced at least a 50 percent reduction in motor vehicle death rates in this 80-year period. At the beginning of the period, motor vehicle death rates are at its highest level and experience a decline toward the end of World War II in 1945. The age-adjusted rates then go through a cycle of ups-and-downs to peak in the late-1960s. From 1970 to 1975, motor vehicle death rates experience a precipitous, followed by a slower, decline toward 2014.

In Figure 2.2, I turn my attention to the absolute black-white difference in age-adjusted motor vehicle death rates from 1934 to 2014 (represented by the black line) and the black-white difference in age-specific motor vehicle death rates from 1969 to 2014

[2] For example, the 1934 rate is the unweighted average of the rates from 1933, 1934, and 1935.

(represented by the 5 other colors). First focusing on the age-adjusted rates, I find that black women have almost always maintained an advantage relative to whites with the exception of several years in the 1950s while black men's rates have almost always been higher than those of white men with the exception of a few years around World War II. The most striking finding is that the 1950s marks the beginning of approximately 20 years when black men experience most elevated age-adjusted death rates compared to white men. In more recent decades, the black-white difference in age-adjusted motor vehicle death rates are converging for both men and women.

The absolute differences in age-specific rates reveal a few notable trends. First, black men and women ages 15 to 24 experience a persistent advantage in motor vehicle death rates compared to their white counterparts, but they are gradually losing their advantage particularly from 1980 to the late-1990s. For men, there is also a large absolute disadvantage for blacks ages 45 to 64 relative to whites from 1969 that diminishes over the years. Meanwhile, the black-white difference for women ages 25 to 64 oscillates throughout the period, first increasing from the early-1980s to mid-1990s then decreasing toward early-2000s. Similarly, black men ages 25 to 45 experience an increasing disadvantage from the early-1980s to late-1990s.

Because levels of motor vehicle death rates are declining over time, absolute differences might not serve as the best indicator for illustrating black-white disparities especially in recent years and for age groups that experience lower death rates. Figure 2.3 displays the black-white ratio in age-adjusted and age-specific motor vehicle death rates with a log-scale. A couple of interesting trends emerge in this figure. The first is the persistence of the disadvantage among black men ages 45 to 64. Since 1969, black men in this age group sustain the largest black-white ratio in motor vehicle death rates for over 30 years. Second, the uptick in the black disadvantage for certain age groups, especially among men, since the Great Recession becomes more prominent. I will discuss the implications of these findings toward the end of the chapter since the recent timeframe is not at the core of this chapter.

To summarize the dynamics of the age-specific trends above, I observe rising black-white differences for most age groups 15 to 64 from the early-1980s to the mid-1990s. For certain adult age groups, I also find a declining black-white difference from the 1990s to the 2000s.

Conceptual Framework and Hypotheses

This chapter focuses on proximate and distal mechanisms that could explain the black-white differentials in motor vehicle fatality rates and changes over time. Figure 2.4 presents an overview of these mechanisms, which shows socioeconomic status as a distal cause of motor vehicle death rates by influencing proximate causes of exposure and risk.

I first disaggregate motor vehicle death rate into exposure and risk components (the decomposition is described further below in the methods section). Exposure refers to the risk of motor vehicle death simply through traveling — the more trips one makes, the greater the chance of motor vehicle crash and death. The risk component captures factors outside of exposure such as differences in driving behaviors, road quality, and quality of vehicles that affect motor vehicle death rates while holding travel amount constant. In my framework, socioeconomic status is a distal factor that can influence both the exposure and risk components. One the one hand, higher socioeconomic status is associated with greater mobility and higher rates of travel, which can increase motor vehicle fatality rates through exposure (Pucher et al., 1998). However, the consensus in the literature is that higher socioeconomic status is linked associated with lower motor vehicle death rates (Cubbin et al. 2000a; Cubbin et al. 2000b; Denney and He, 2014; Gove, 1973). The idea is that those who are socioeconomically advantaged possess more knowledge, money, prestige, and other resources that they can leverage into better health and mortality outcomes (Link and Phelan, 1995).

In Section 2, I first look at the changes in the black-white ratio in exposure and risk over time to see how they might account for changes in the differentials in death outcome. One possibility is that blacks are catching up to whites in terms of exposure during this period, which could account for the increase in the black-white differentials in motor vehicle death rates from 1980 to 1990s. There is evidence that blacks were travelling at much lower rates than whites earlier in the period in 1969, particularly among the young adults, where I observe the largest differences in motor vehicle death rates between blacks and whites. The 1969 National Household Travel Survey (NHTS) finds 86 percent of whites made their trips in cars compared to 69 percent of blacks and other races (Randill et al., 1973). But among 16 to 20 year olds, whites made an estimated 52 percent of their trips as automobile drivers compared to just 17 percent of teens of black and other races. These results on the distribution of trips by mode indicate much lower access to automobiles — and possibly as a proxy for limited mobility — among blacks during the teenage and young adult years. Perhaps as blacks accumulate more wealth to own cars and face less discrimination on the road after the Civil Rights Movement, they will start to catch up to whites in terms of exposure.

Another hypothesis is that the black-white differential in risk narrows during the latter part of study period and accounts for the observed declines in mortality differences from the 1990s. The narrowing of the black-white gap in socioeconomic during this time could play a role. For example, Iceland (2017) shows that the black poverty rates dropped by 10 percentage points from the early-1990s to the early-2000s. As discussed below, socioeconomic status is negatively associated with behaviors drunk driving and lack of seatbelt use. Another possibility could be related to new policies enacted during this time. Since the late-1980s, many important pieces of legislations were passed at the state-level to address harmful individual behaviors leading to motor vehicle deaths. Most notably, drunk-driving laws gained traction at the federal level in 1984 and continued to strengthen at the state-level during the next decade and half (Silver et al., 2013). Research finds states with stronger policies to have lower motor vehicle death rates (Silver et al., 2013). In fact, there is evidence that stronger state-level policy is associated with lower black-white disparities in seat belt use (Briggs et al., 2006). Although I do not test this relationship explicitly, it is possible that the legislations passed during this critical time contributed to lowering the risk of motor vehicle deaths among blacks relative to whites.

In Section 3, I use the National Health Interview Survey with mortality follow-up to evaluate the extent to which socioeconomic variables can explain black-white differentials in motor vehicle deaths among prime age adults from 1986 to 2006. As illustrated in the framework in Figure 2.4, better socioeconomic status can lower death rates by operating through the risk component to mitigate risk factors. For example, Cutler and Lleras-Muney (2010) find years of education to be positively associated with seat belt use. Similarly, marriage can help protect against motor vehicle deaths by curbing risk-taking behaviors, such as alcohol consumption and substance abuse (Umberson 1987). Because blacks are more likely to be in poverty, not employed, unmarried, and lower educated, I hypothesize that their socioeconomic disadvantage can account for some or all of excess motor vehicle deaths (Iceland 2017).

Data and Methods

Vital Statistics

Motor vehicle death rates shown in Section 1 come from various sources from the Center for Disease Control and Prevention (CDC). I include the age-adjusted motor vehicle death rate per 100,000 using the 2000 standard population by sex and race from 1933 to 2015. The year 1933 is chosen because it is the first year when all the U.S. States became part of the National Vital Statistics System whereas before 1933 the Death Registration States did not include mortality from every state in the country.

For years 1933 to 1967, I converted the age-adjusted motor vehicle death rates from PDF versions of the HIST293 tables for years 1933-1949, 1950-1959, and 1960-

1967 into usable form (Centers for Disease Control and Prevention, n.d.-a, n.d.-b, n.d.-c). These tables are based on historical data from the National Center for Health Statistics' National Vital Statistics System with the age-adjusted rates calculated internally by the CDC. From 1968 to 2015, I use the age-adjusted and age-specific rates queried from the CDC's Wide-ranging OnLine Data for Epidemiologic Research (WONDER) database (Centers for Disease Control and Prevention, 2016). Age-specific rates are presented for the following age groups: 5 to 14, 15 to 24, 25 to 44, 45 to 64, and 65 to 84. These five, broader age groups are determined because they represent distinct groups that experience similar levels of motor vehicle death rates. For example, motor vehicle death rates are highest for 15 to 24 year-olds who are often newly licensed drivers. Data on motor vehicle death rates for these specific age groups are not readily accessible before 1968.

Although this chapter focuses on motor vehicle deaths for non-Hispanic blacks and whites, the categories of race and ethnicity in mortality data have changed during the study period. The HIST293 tables from 1933 to 1967 only report race as white and all other. Since no more than one percent of the non-white population in the United States before 1968 was black, I refer to the trend for the "all other races" category as black (Gibson and Jung, 2005). Beginning in 1968, race is categorized as white, black, and other in CDC WONDER and Hispanic status is introduced to the CDC WONDER database starting in 1999. As such, I include deaths from blacks and whites during 1968 to 1998 and further constrain the deaths to those for non-Hispanic blacks and whites after 1999. Although I was not able to remove deaths for the Hispanic and Latino population before 1999, their population only ranged between 4.7 and 9 percent from 1970 to 1990 (Gibson and Jung, 2005).

The categorization of motor vehicle deaths has also changed over the study period. Table 2.1 summarizes the International Classification of Disease (ICD) codes for motor vehicle deaths. Classification of motor vehicle deaths is relatively consistent across the ICD versions (Centers for Disease Control and Prevention, n.d.-d).

National Household Travel Survey

Next, I use the National Household Travel Survey (NHTS) to examine the role of travel amount in accounting for black-white differences in motor vehicle death rates over time.[3] The NHTS is a nationally representative household survey conducted every 5 to 8 years in 1969, 1977, 1983, 1990, 1995, 2001, and 2009. The travel survey collects information about the household, vehicles in the household, persons in the household, and travel information for persons in the household on an assigned travel day. The agency that collects the survey data then calculates travel weights that allow researchers to estimate annual miles travelled and trips taken for specific demographic groups.

In order to align the travel and vital statistics data, I analyze detailed travel data for non-Hispanic black and white respondents between the ages of 15 and 84. Travel information for ages 14 and under are not included in the analysis because the NHTS has not consistently collected all travel information from this age group. In Table 2.2, I show

[3] Formerly, the National Personal Transportation Survey from 1969 to 1995.

the unweighted sample sizes for the surveys. In general, the number of respondents included in the survey has increased substantially over the years to over 200,000 persons in 2009. My sample size with the aforementioned age and race constraints usually amounts to between 50 and 80 percent of the total respondents.

A few limitations on data use and restrictions should be noted. First, because micro data are not available for the 1969 survey, I do not include results from this survey. Second, the 1977 travel micro data are not available publicly but was requested through the Federal Highway Administration. All the other recent surveys are available on the NHTS website. Finally, race and ethnicity is only collected at the household level from the main household respondent (i.e. respondent number one from each household) starting with the 1990 survey. The assumption is that each person in the household is of the same race and ethnicity as the main person who completes the survey for the household. In this chapter, I only include persons from households whose main respondent is of non-Hispanic black or white race. Additionally, as Hispanic ethnicity is not specifically collected for the 1983 and earlier surveys, I am not able to identify non-Hispanic respondents and thus include respondents from all ethnicities. Limitations of racial identification in the survey will be addressed in the discussion section.

I leverage the travel survey to achieve the decomposition in Equation 2.1. The equation notes that motor vehicle death rate during a given year for a race-, sex-, and age-specific group can be factored into a risk and exposure component with the former as number of deaths per amount of travel and the latter as amount of travel per 100,000 person-years. In this paper, I use total trips travelled as the proxy of travel amount. A trip is defined as traveling from one address to another. First, I calculate the annual trips made per person for each population group in each survey year. Then, I multiply this annual trips made per person measure by the number of persons from the CDC WONDER database to obtain total trips travelled for each race, sex, and age group in each survey year. With this measure, I examine how the black-white ratio in the risk and exposure components changes over time.

$$\text{Motor Vehicle Death Rate} = \frac{\text{Deaths}}{\text{Unit of Travel}} \times \frac{\text{Unit of Travel}}{\text{100,000 Person Years}}$$

(Eq. 2.1)

Although the NHTS surveys also enable estimates for person-miles travelled, I do not examine this measure because the survey collection methods for trips have changed over the years. Until 1995, the NHTS records trips and travel information based on respondents' memory recalls and later replaced this method with a travel diary (U.S. Department of Transportation, 2011). For consistency across time, I choose to use trips as the unit of travel in this chapter.

National Health Interview Survey

To examine socioeconomic factors that could explain the risk of motor vehicle deaths for black compared to white adults, I leverage the National Health Interview Survey (NHIS) with mortality follow-up. The NHIS is a nationally representative, cross-sectional household survey conducted by the National Center for Health Statistics. I pool the 1986 to 2001 years of NHIS linked to the Linked Mortality Files through 2006, which gives a mortality follow-up period of up to 21 years. The NCHS is responsible for the process of linking the NHIS to the LMF, and the IPUMS Health Surveys (formerly, the Integrated Health Interview Series) provided the complete, harmonized dataset (Blewett et al., 2016).

For this section, I focus on adults ages 30 to 64 for a couple of reasons. First, there exists a mortality crossover for blacks and whites where whites exhibit higher motor vehicle death rates for ages 15 to 24 but this pattern reverses for adult ages 25 to 64. Including deaths for younger adults could obscure the risk of blacks. In this study, the reason the lower bound age is set at 30 rather than 25 is because this motor vehicle mortality cross over for occurs in the late-20s in this specific dataset. Second, the socioeconomic variables that will be included into the model such as educational attainment and marriage are more likely to be in flux during younger adult ages.

I first select for 615,682 non-Hispanic black and white adults in the study period who were interviewed between the ages of 30 and 64 who provided valid, non-missing responses on race. Of those, I dropped 7.7 percent of respondents due to having ineligible mortality linkage status or non-positive weights. Next, one percent of respondents was dropped because they were missing main socioeconomic variables. After these exclusions, the final data includes 562,884 respondents with 878 motor vehicle death outcomes.

For my analysis, I estimate the risk of death from motor vehicle deaths using Cox proportional hazard models with age as the time scale. The models are weighted using NHIS mortality weights that account for respondents who were ineligible to be matched to the Linked Mortality Files. The multivariate results also report robust standard errors clustered at the household level. Respondents are right-censored if they die from causes of death other than motor vehicle deaths before age 65, if they survive at the end of the follow-up period, or if they reach age 65 before the end of the follow-up period. Survival analysis was performed using Stata 13 (StataCorp 2016).

The dependent variable is a dummy variable with motor vehicle deaths as the outcome with those died from other causes and those who survived at the end of follow-up as the referent group. Deaths that occurred before 1999 align with specific codes from the 9th revision of the International Classification of Disease (ICD-9). From 1999 forward, deaths were recorded based on the 10th revision of the ICD. Again, these ICD codes that correspond with motor vehicle deaths are found in Table 2.1.

Main explanatory variables include race, employment, marital status, poverty, and education. Non-Hispanic black is a dummy variable with non-Hispanic white as the referent group. Employment status is a categorical variable with employed as the referent group and unemployed and not in the labor force as the other two levels. For marital status, the combined group of never married, divorced, separated, and widowed is compared to the married referent group. The poverty variable is coded into three categories with at or above poverty threshold (referent group), below poverty threshold, and unknown or undefined. Due to an insignificant proportion of those with unknown or undefined poverty status, I include this category rather than remove these respondents. The education variable has three levels: less than high school, high school, and more than high school (referent group).

Other variables are included as controls and are chosen because they are also associated with motor vehicle death outcomes. Gender is dichotomously coded with female as the referent group. Region of the United States includes the West, South, Midwest, and the Northeast (referent group). Interview year is treated as a continuous variable. Finally, I include metropolitan residence, defined as those who live in a Metropolitan Statistical Area, as a dummy variable.

Section 2. Exposure and Risk Changes Over Time

In this Section, I describe the trends of the decomposed risk and exposure components using the NHTS from 1977 to 2009 and show how they relate to the mortality trends from Section 1. Figure 2.5 and Figure 2.6 illustrate the age-specific black-white ratio in exposure (10 million trips per 100,000) and risk (deaths per 10 million trips) by gender. First looking at Figure 2.5, I find that blacks of all age groups make fewer trips compared to whites. For women, the black-white ratio in exposure shows an upward trend from 1977 to 2009 for all age groups except for ages 65 to 84. For men, the black-white ratio in exposure for ages 15 to 44 inches closer to the levels of whites from 1983 to 2001. Figure 2.6 describes the changes in the risk component for blacks relative to whites over time. Most notably, blacks aged 25 and over experience higher risk of motor vehicle death throughout the entire period (except for women 65 and over in 1977) while blacks ages 15 to 24 experience a consistently lower risk compared to whites.

How do these trends of exposure and risk relate to the black-white differences in motor vehicle death rates? Recall the four notable trends from Section 1:

1. Increase in the black-white differentials in death rates for women 25 to 64 and men 25 to 44 from 1980 to the late-1990s.
2. Decrease in the black-white differentials in death rates for women 25 to 64 from 1995 to late-2000s.
3. Decrease in the black-white differentials in death rates for men 45 to 64 during the whole period, especially in the 2000s.
4. Increase in the black-white differentials in death rates for women and men 15 to 24 from 1980 to 2000 for women and 1995 for men.

I find that a relative increase in exposure for blacks is responsible for trend 1. For women 25 to 64, blacks were making almost 30 percent fewer trips than whites in 1983 compared to at most 13 percent fewer trips in 1995. Meanwhile, black men 25 to 44 was making 23 percent fewer trips than whites in 1983 to about the same number of trips in 2001. At the same time, the trend for risk does not change significantly for these groups. In terms of trends 2 and 3, I find that a decrease in the black-white ratio in risk accounts for these declines in mortality differentials even as exposure differentials have increased or stayed the same. In 1995, black women 25 to 64 experience at most 21 percent higher risk compared to whites, but this number drops to 6 percent in 2009. Most dramatically, black men 45 to 64 experience almost double the risk as white men in 1977 compared to just 15 percent higher risk in 2009, largely through a decline in the last decade. Finally, trend 4 for women corresponds with first an increase in the exposure ratio to 1995 followed by an increase in the risk ratio from 1995 to 2001. For men, I find both an increase in exposure and risk ratios from 1983 to 1995 to account for the changes in trend 4.

These results illustrate how risk and exposure account for the changes in the black-white differentials since 1977. To summarize, black adults are catching up to whites in terms of exposure from 1980 to the 1990s, and this convergence plays a role in the increases in motor vehicle death differentials. While blacks gained mobility and presumably greater access to automobiles during this time, it did adversely impact their motor vehicle death outcomes. For adults, I also find that risk plays a role when I observe substantial declines in the motor vehicle death differential, particularly after the 1990s. This finding suggests that blacks' risk — although higher than whites' — declined in recent decades and contributed to corresponding convergences in motor vehicle death rates. For young adults 15 to 24, the story is a little different. Both relative increases in exposure and risk appear to influence the narrowing black advantage in motor vehicle death rates. Given the much lower access to automobile travel among blacks when the first travel survey was conducted 1969, closing the gap in exposure for this age group is not unexpected. However, this is the only age group where risk increases over time for blacks relative to whites and contributes to increases in the death rate differentials. The results allude to increasing dangers of travel for black teenagers and young adults.

Sensitivity Analysis

In a supplementary analysis, I show the same graphs above without walking trips. The purpose of this analysis is to eliminate pedestrian trips which may be taken under vastly different conditions (i.e. walking unprotected in the middle of the street versus in a protected green space) compared to vehicle trips that almost always occur on a public road. Secondly, eliminating walking trips makes for a fairer comparison between blacks and whites since they differ in mode of travel, with blacks more likely to travel as pedestrians compared to whites. Although walking trips recorded throughout this survey series generally amount to a little less than 10 percent of all recorded trips, this number increases to 28 percent for certain age, race, and gender groups. With that said, Figure 2.7 and Figure 2.8 show the black-white ratio in exposure and risk, respectively. Removing pedestrian trips do not change the overall patterns between blacks and whites, likely because walking trips account for a relatively small number of total recorded trips.

Section 3. Distal and Socioeconomic Factors

Table 2.3 presents weighted percentages and means of the variables by race. The third column shows the p-values for the tests of differences in means (two sample t-test) and proportions (chi-squared) between the two samples. Compared to whites, blacks are more likely to from a motor vehicle death. In terms of the demographics, blacks are also more likely to be female, reside in the South and inside of a metropolitan area, and younger.

The two groups also differ in terms of marital status, employment status, poverty status, and education in ways that suggest blacks are at a socioeconomic disadvantage. The differences in the social and demographic variables between the two groups align with what has been documented about the conditions of blacks and whites during this time and could certainly play a significant role in explaining the higher motor vehicle deaths among blacks in this sample of adults (Farley and Allen, 1987).

Building on the descriptive statistics, I now move onto multivariate analysis that examines the risk of motor vehicle deaths for black adults compared to white adults controlling for socioeconomic variables. Table 2.4 presents Cox hazard ratios (HR) across six models. Model 1 examines the association of black race and subsequent risk of motor vehicle death. Blacks are 1.35 times ($p<0.01$) more likely than whites to experience a motor vehicle fatality controlling for interview year and gender. The control variables in this model are also significant. Compared to females, males experience a risk over twice as high (HR = 2.09, $p<0.001$) in Model 1 and all other models thereafter. Those interviewed in more recent years are less likely to die in a motor vehicle death. Each subsequent year of interview is associated with a six percent lower risk of dying from a motor vehicle crash ($p<0.001$). The year coefficients and significance are similar in subsequent models. Model 2 adds region and metropolitan status to the model. The addition of these two variables slightly attenuates the black coefficient (HR = 1.32, $p<0.01$). Respondents in the Midwest and South are significantly more likely to die in a motor vehicle death than those in the Northeast United States. Again, the regional variations in hazard ratios remain unchanged in later models. Finally, metropolitan residents are almost 40 percent ($p<0.001$) less likely to die from a motor vehicle crash compared to those who live outside metropolitan areas.

In Models 3 to 6, I look at how the black coefficient changes as socioeconomic variables are added. Model 3 introduces employment status. Including employment status attenuates the black coefficient to 1.30, which is still significant at the 0.05 level. Individuals who are not in the labor force also experience an elevated risk of motor vehicle death (HR = 1.30, $p<0.05$) compared to the employed, but I do not find the unemployed coefficient to be significant.

Model 4 adds marital status and renders the black coefficient marginally significant ($p<0.10$). Accounting for marital status and other controls, blacks are 22 percent more likely to experience a motor vehicle death compared to whites. Those who are not married are 45 percent more likely ($p<.001$) to die over the follow-up period from a motor vehicle death than those who are currently married.

In Model 5, I examine the association between poverty and motor vehicle death risk. Those who are in poverty are almost twice as likely (HR = 1.98, $p<0.001$) to experience the death outcome as those who are not in poverty. The missing poverty coefficient is marginally significant. Accounting for poverty level reduces the black coefficient to 1.19, meaning that blacks experience a 19 percent higher (though non-significant) risk of motor vehicle death.

Model 6 adds educational attainment to the basic model with controls. As expected, the less educated experience significantly higher risks of motor vehicle death. Compared to those with more than high school education, high school educated individuals are over 50 percent more likely (HR = 1.51, $p<0.001$) while those with less than high school education are over twice as likely (HR = 2.01, $p<0.001$) to die from a motor vehicle in the follow up period. Accounting for education in Model 6 attenuates the hazard ratio for blacks to 1.12 ($p<0.10$).

Supplementary Analysis

In Table 2.5, I focus on the combined effect of including all the socioeconomic variables followed by models of black interaction terms. Model 1 from this table is the full model that includes employment, marital status, poverty, education, and all the previous controls. I find that including all the variables further reduces the black coefficient to a non-significant 1.07. The explanatory variables that are left significant in Model 6 are marital status, poverty, and education. As previously mentioned, these variables are proxies for socioeconomic status and social support that serve as distal factors influencing motor vehicle outcomes through proximate factors of risk and exposure. In this context, the socioeconomic factors are more likely to operate through the risk component rather than exposure because the hazard ratios for blacks are reduced when controlling for socioeconomic status differences. The possible mechanisms will be discussed in the next section.

Models 2 to 4 in this table includes the controls, one of the main socioeconomic variables at a time, and the black interaction term with the variable. Examining the black interaction effects could identify socioeconomic variable that benefit or harm blacks and whites differently. I do not find significant black interaction terms for marital status (Model 2) and education (Model 4). However, for poverty in Model 3, there is some evidence that poverty may be less harmful for blacks than whites in terms of motor vehicle death outcome (HR for black X below poverty = 0.60, $p<0.10$). One explanation for this finding is that blacks may be in deeper poverty than whites or may be more materially deprived in poverty in a way that reflects in lower car ownership and travel. This explanation would point to a protective mechanism through lowering exposure despite experiencing worse socioeconomic conditions. Other than poverty, I do not find evidence that the other socioeconomic variables in this study differentially impact blacks and whites in their motor vehicle death outcome.

Discussion and Conclusion

This chapter has provided a demographic analysis of the black-white differentials in motor vehicle fatalities for the greater part of the 20th Century with a focus on trends from the 1970s forward. In Section 1, I find both the age-adjusted and several age-specific motor vehicle death rates between blacks and whites have converged in recent decades since 1970 and 1980 when they experience the largest differentials. Most notably, blacks 15 to 24 years old of both sexes in 1980 experienced a substantial mortality advantage that has since attenuated in recent decades. On the other end of the spectrum, black men ages 45 to 64 were highly disadvantaged in the early 1970s but experience near parity with their white counterparts in the late 2000s. Finally, I observe an increase in the black-white differentials in death rates for several adult age groups until the late-1990s, when it is followed by a decrease in the differentials.

In Section 2, I examine how black-white differentials in exposure and risk over time can help explain the mortality patterns described in Section 1. The results support the hypothesis that blacks are catching up to whites in tripmaking rates from 1980 to 1990s, accounting for the increases in the black-white differentials in motor vehicle death rates for certain adults. After this time, I also find reductions in excess risk of blacks to correspond with certain decreases in these black-white differentials in motor vehicle death rates. These results underscore the importance of the changing differentials in exposure and risk over a 30-year period since 1977. In 2009, blacks in every age group except for the elderly are making at least 88 percent as many trips as their white counterparts. Narrowing the gap in tripmaking rates for blacks suggests greater mobility and access to the same modes of transportation as whites. Beyond that, the increase in exposure could also reflect a growth of job opportunities for blacks or more resources for engaging in social and recreational activities that induce travel. After making gains in exposure, blacks see further reductions in the risk component, perhaps as a result of improvements in social conditions over time. As mentioned previously, risk could encompass a host of individual-, environmental-, and contextual-level factors. Although teasing out these factors extends beyond the scope of this chapter, I can say that the reduction in the racial differentials in deaths per unit of travel in recent decades paints an optimistic picture, though there is still progress to be made.

Section 3 examines the key socioeconomic factors that may account for the higher motor vehicle death rates among black adults. Using Cox proportional hazard models, I find that a host of socioeconomic variables together — poverty, marriage, and education — explains away the adult black disadvantage in motor vehicle fatality from 1986 to 2006. These distal factors are hypothesized to reduce the black disadvantage in motor vehicle death rates through the risk component. One mechanism socioeconomic factors can influence motor vehicle death outcomes is through modifying individual behaviors. As mentioned before, those with more years of education are more likely to use seat belts (Cutler and Lleras-Muney, 2010). Marriage can also reduce risk-taking behaviors related to driving, such as alcohol consumption (Umberson, 1987). Beyond individual behaviors, low socioeconomic status can also reflect lacking adequate resources to protect oneself from motor vehicle crash and death. For example, those in poverty may be less likely to have safer vehicles or may only travel as pedestrians, which can increase risk of death upon a crash. Worse individual socioeconomic conditions can further be associated with living in poorer neighborhoods with less safe built environments that are more conducive to motor vehicle crashes (Morency et al., 2012). Future research should examine the specific mechanisms through which these socioeconomic factors can influence motor vehicle deaths for blacks and whites.

This chapter raises additional questions that should be addressed in future research endeavors. First, the patterns in Figure 2.2 and Figure 2.3 suggest that the black-white differentials may fluctuate with macroeconomic changes, especially for men. For example, in Figure 2.2, the black-white differentials in age-adjusted motor vehicle death rates reach parity (or close to it) in the Recession of the early 1980s and the Great Recession to the late 2000s. Previous literature finds blacks are the first ones fired when unemployment climbs (Couch and Farlie, 2010). Future studies should investigate how macroeconomic conditions might impact travel patterns as a result of work for blacks and whites.

Second, despite the recent signs of parity noted in Section 2, the results reveal a disconcerting rebound in the higher black motor vehicle death rate during the post-Great Recession years, especially for working age men. Future research should understand how much of this uptick is due to broader economic conditions and how much is due to other emerging factors. Moreover, the black-white differentials among children 5 to 14 have risen to highest levels since 1969. Again, researchers need to monitor this nascent trend and understand why black children are experiencing this unprecedented disadvantage.

Finally, in 2009, blacks are still traveling at a lower rate compared to whites while dying at a higher rate of motor vehicle crash per unit of travel (except for age 15 to 24). In the next chapter, I quantify how much the risk and exposure components account for the black-white differentials in motor vehicle deaths for different modes of travel.

There are limitations to the findings presented in this chapter. First, the NHTS does not collect information on trips taken during work. This limitation could lead to underestimates of exposure amount for those who make work trips, including those in the transportation industry (e.g. cab drivers). Data from the Bureau of Labor Statistics show blacks are overrepresented in transportation and materials moving occupations, suggesting that the NHTS might underestimate exposure for blacks if work travels are not collected (Bureau of Labor Statistics, 2017). If that is the case, the risk component (deaths per unit of travel) would be lower than estimated in this paper.

As mentioned earlier, another limitation with the NHTS is that race is only collected for the main respondent of each household for surveys in 1990 and later. Using the 1977 and 1983 surveys where race was collected for every individual, I find only about one percent of the households in these surveys are mixed-race, meaning that more than one race is reported in the household. Although interracial marriage has increased since 1983, I do not expect mixed-race households to be a large problem for this survey (Pew Research Center, 2015).

Furthermore, the results using NHIS do not imply causation. The associations I find between the key socioeconomic variables and motor vehicle fatality outcome could be a result of other unknown factors. For example, those who possess lower socioeconomic status may be a self-selecting group that also engages in risky driving behaviors. Future research may be able to empirically test the causal effect of these explanatory variables on deaths from motor vehicle crashes.

This study has revealed trends in the black-white differentials in motor vehicle fatalities from 1934 to 2014. The results underscored the progress that has been made in reducing racial inequalities in motor vehicle fatality rates in the past several decades and also provide future directions for addressing existing disparities.

Table 2.1 International Classification of Disease (ICD) Revision Number, Years, and Codes for Motor Vehicle Deaths

ICD Revision	Years Used	Code
4th	1930-1938	206, 208, 210, 211
5th	1939-1948	170
6th	1949-1957	E810-E835
7th	1957-1967	E810-E835
8th	1968-1978	E810-E823
9th	1979-1998	E810-E825
10th	1999-present	V02-V04, V09.0, V09.2, V12-V14, V19.0-V19.2, V19.4-V19.6, V20- V79, V80.3-V80.5, V81.0-V81.1, V82.0-V82.1, V83-V86, V87.0- V87.8, V88.0-V88.8, V89.0, V89.2

Source: Center for Disease Control and Prevention, n.d.-d

Table 2.2 Unweighted Sample Sizes, National Household Travel Survey, 1977 to 2009

Survey Year	Total Respondents	Sample Size	% of Total Respondents	Race and Ethnicity Included
1977	51,194	27,261	53.3	Whites and blacks of all ethnicities. Race and ethnicity are collected at individual level
1983	17,382	9,439	54.3	
1990	48,385	28,743	59.4	Non-Hispanic whites and blacks. Race and Hispanic ethnicity are collected for the main household respondents
1995	95,360	75,365	79.0	
2001	160,758	113,929	70.9	
2009	308,901	224,129	72.6	

Source: NPTS 1977, 1983, 1990, 1995; NHTS 2001, 2009

Table 2.3 Weighted Distribution of Social and Demographic Variables by Motor Vehicle Death Outcome, National Health Interview Survey, U.S. Adults 30-64, 1986-2001

Variables	Whites (N=481,709)	Blacks (N=81,175)	p-value
Motor Vehicle Death			*
Yes	0.15	0.18	
No	99.85	99.82	
Gender			***
Male	49.04	44.53	
Female	50.96	55.47	
Interview Year (Mean)	1,993.92	1,994.12	*
Region			***
Northeast	21.12	18.17	
Midwest	26.51	18.81	
South	32.86	54.64	
West	19.52	8.39	
Metro Status			***
Inside MSA	76.76	86.18	
Outside MSA	23.24	13.82	
Employment Status			***
Employed	77.95	72.38	
Unemployed	2.26	4.18	
Not in Labor Force	19.80	23.44	
Marital Status			***
Married	76.89	52.83	

Not Married	23.11	47.17	
Poverty Status			***
Above Poverty Line	84.94	67.66	
Below Poverty Line	5.08	16.26	
Unknown or Undefined	9.98	16.08	
Education			***
Less Than High School	12.40	22.28	
High School	36.81	38.84	
More Than High School	50.78	38.88	
Age (Mean)	44.44	43.42	***

* $p<0.05$, ** $p<0.01$, *** $p<0.001$
Source: NHIS 1986-2001

Table 2.4 Cox Hazard Ratios (SE) for U.S. Adults 30-64, 1986-2001 (N=562,006, Motor Vehicle Deaths=878)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Black (ref = white)	1.35**	1.32**	1.30*	1.22+	1.19	1.22+
	(0.14)	(0.14)	(0.13)	(0.13)	(0.13)	(0.13)
Male (ref = female)	2.08***	2.08***	2.19***	2.13***	2.13***	2.10***
	(0.16)	(0.16)	(0.17)	(0.16)	(0.16)	(0.16)
Interview Year	0.94***	0.94***	0.94***	0.94***	0.94***	0.95***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Region (ref = Northeast)						
Midwest		1.40**	1.41**	1.41**	1.40**	1.42**
		(0.17)	(0.17)	(0.17)	(0.17)	(0.17)
South		1.70***	1.70***	1.71***	1.66***	1.67***
		(0.19)	(0.19)	(0.19)	(0.19)	(0.19)
West		1.26	1.26	1.25	1.24	1.31*
		(0.16)	(0.16)	(0.16)	(0.16)	(0.17)
Metro Status (ref = Non-Metro)		0.61***	0.61***	0.59***	0.63***	0.65***
		(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Employment (ref = Employed)						
Unemployed			1.40			
			(0.26)			
Not in Labor Force			1.30*			
			(0.13)			
Not Married (ref = Married)				1.45***		
				(0.12)		
Poverty (ref = not in poverty)						
Below Poverty					1.98***	
					(0.23)	

Unknown or Undefined					1.30+	
					(0.18)	
Education (ref = More Than High School)						
High School						1.51***
						(0.12)
Less Than High School						2.01***
						(0.20)

+p<0.10, *p<0.05, **p<0.01, ***p<0.001
Source: NHIS 1986-2001

Table 2.5 Cox Hazard Ratios (SE) with Interaction Terms for U.S. Adults 30-64, 1986-2001 (N=562,006, Motor Vehicle Deaths=878)

	Model 1	Model 2	Model 3	Model 4
Black	1.07	1.34*	1.46**	1.12
	(0.12)	(0.19)	(0.18)	(0.22)
Unemployed	1.15			
	(0.22)			
Not in Labor Force	1.05			
	(0.11)			
Not Married	1.36***	1.50***		
	(0.11)	(0.14)		
Below Poverty	1.54**		2.22***	
	(0.20)		(0.29)	
Unknown or Undefined	1.14		1.51**	
	(0.16)		(0.22)	
High School	1.43***			1.39***
	(0.12)			(0.12)
Less Than High School	1.75***			2.12***
	(0.19)			(0.23)
Black X Not Married		0.81		
		(0.17)		
Black X Below Poverty			0.60+	
			(0.16)	
Black X Unknown or Undefined			0.40**	
			(0.14)	
Black X High School				1.44
				(0.35)
Black X Less Than High School				0.72
				(0.20)

+p<0.10, *p<0.05, **p<0.01, ***p<0.001
All models control for gender, region, metro status, year of interview

Figure 2.1 Age-Adjusted Motor Vehicle Death Rates by Gender from 1934 to 2014 (3-year moving average)
Note: Y-axis scale differs

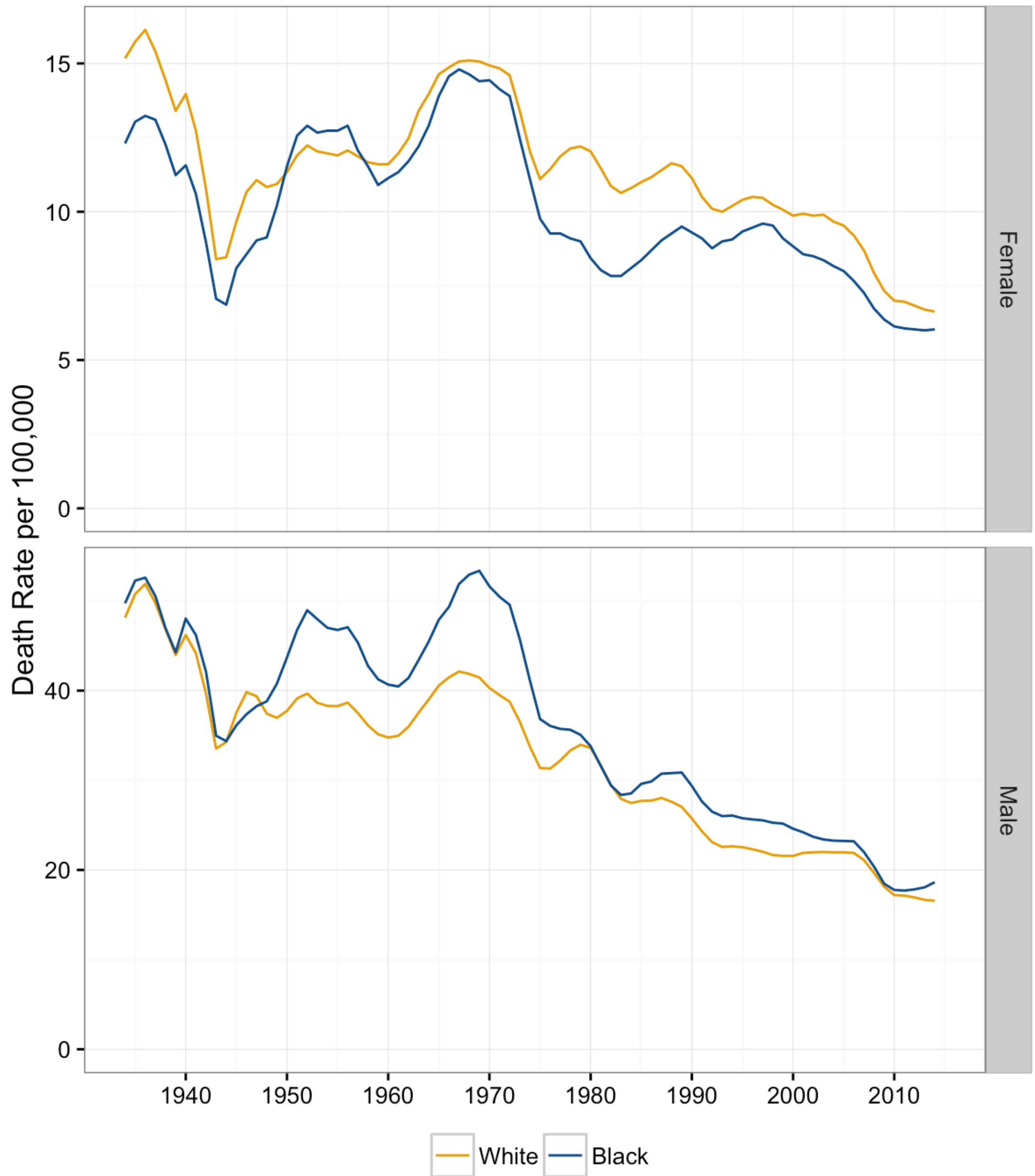


Figure 2.2 Black-White Difference in Age-Adjusted and Age-Specific Total Motor Vehicle Death Rates by Gender from 1934 to 2014 (3-year moving average)
Note: Y-axis scale differs

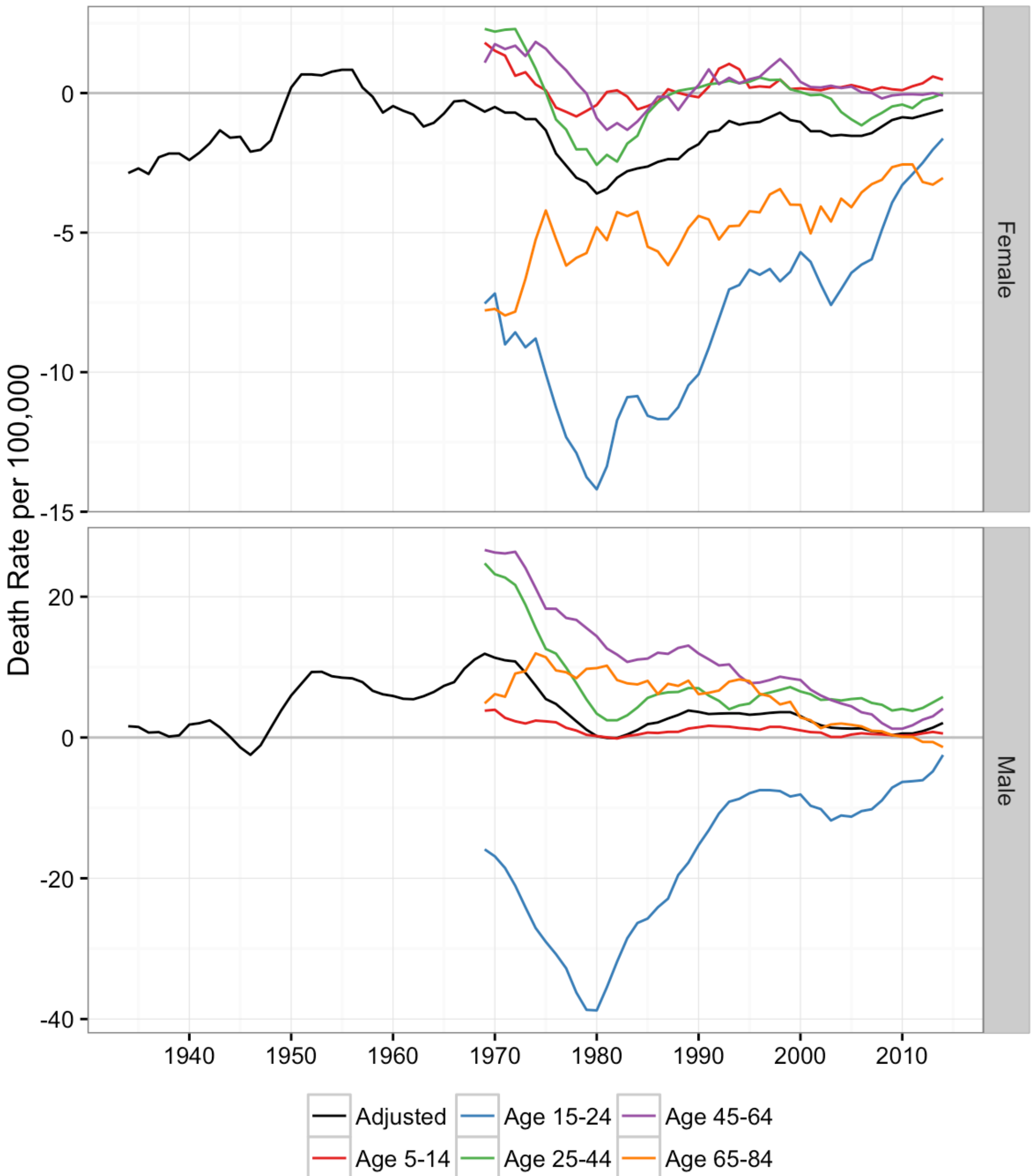


Figure 2.3 Black-White Ratio in Age-Adjusted and Age-Specific Total Motor Vehicle Death Rates by Gender from 1934 to 2014 (3-year moving average)

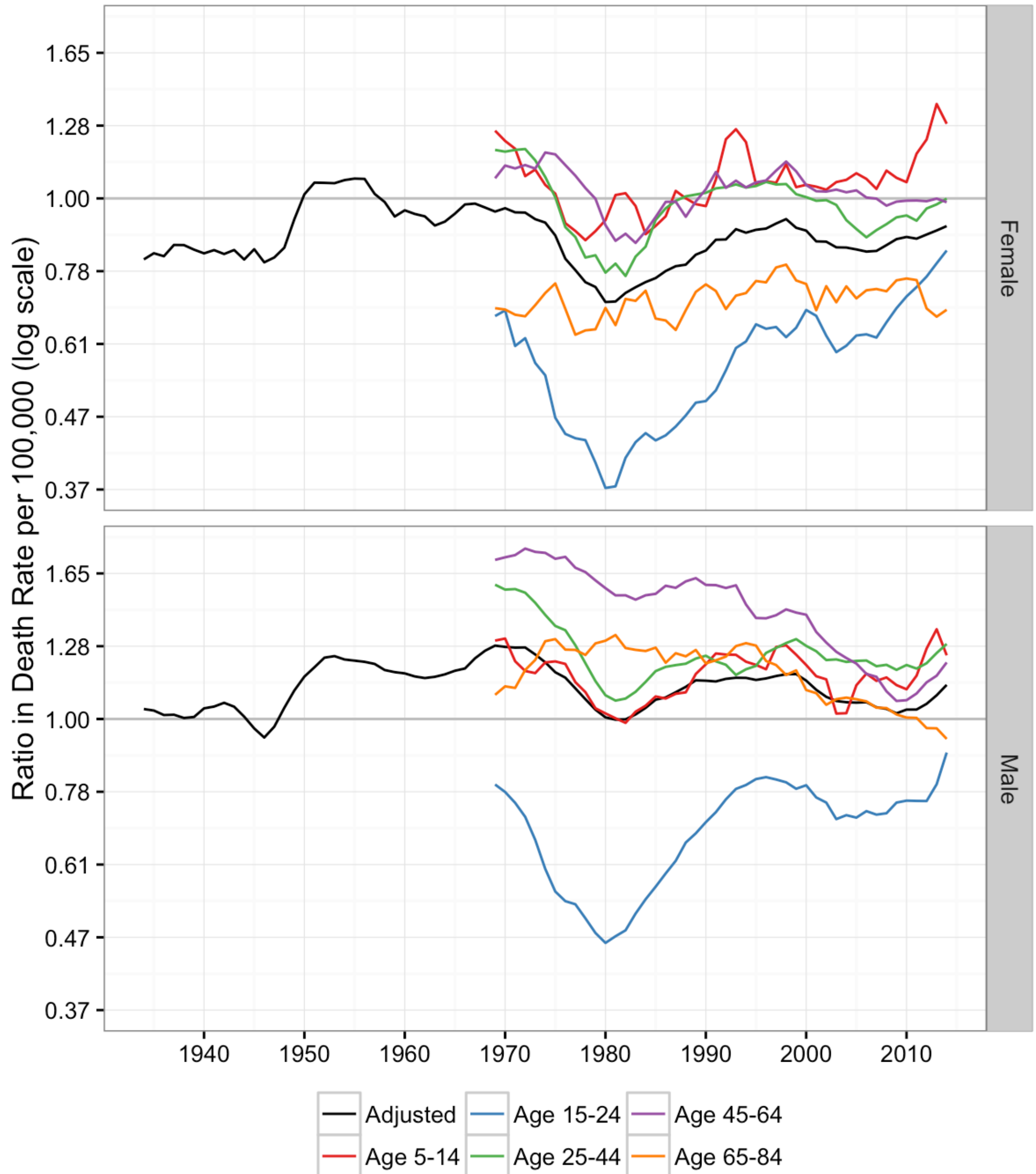


Figure 2.4 Conceptual Framework

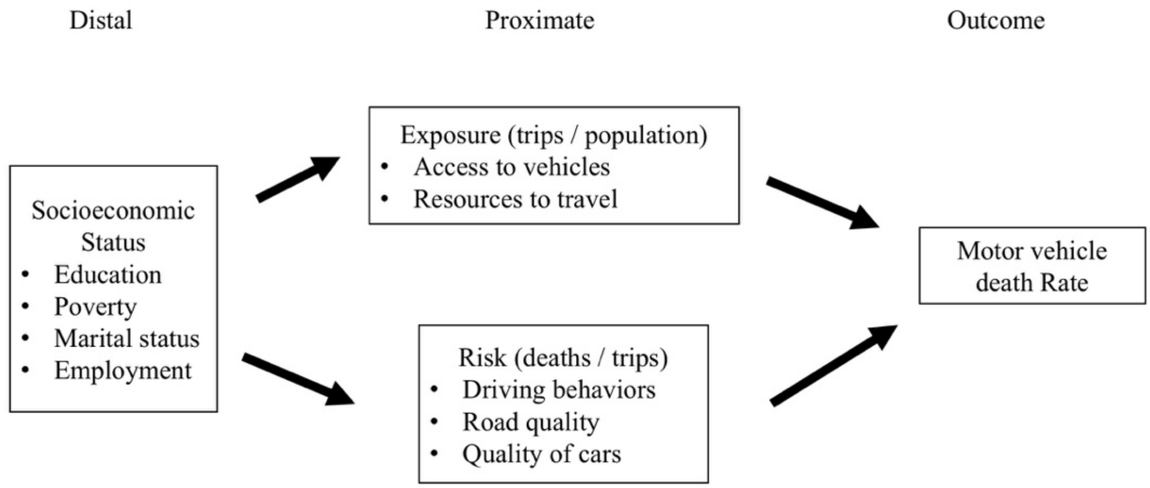


Figure 2.5 Age-Specific Black-White Ratio in Exposure by Gender, 1977-2009

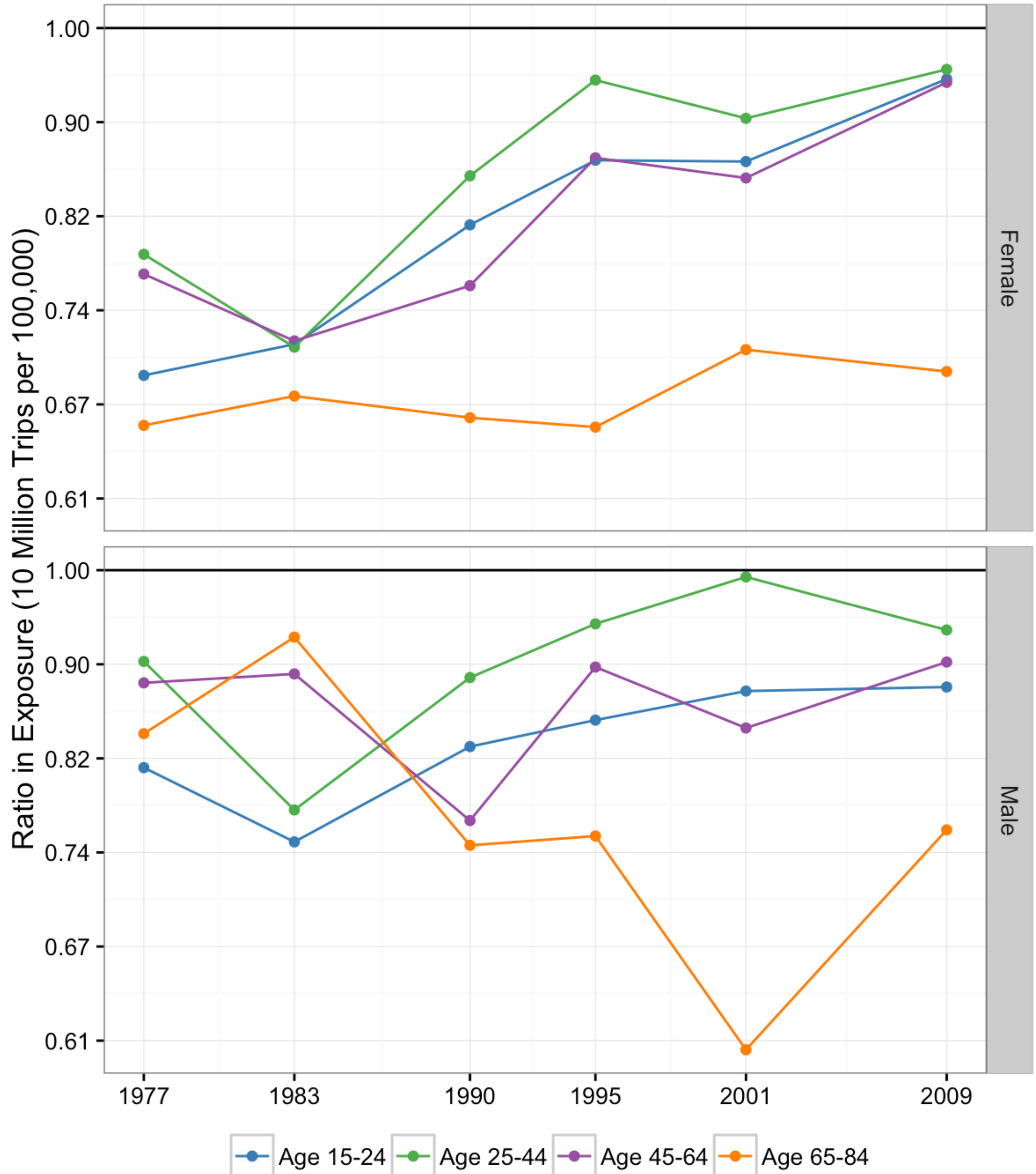


Figure 2.6 Age-Specific Black-White Ratio in Risk by Gender, 1977-2009

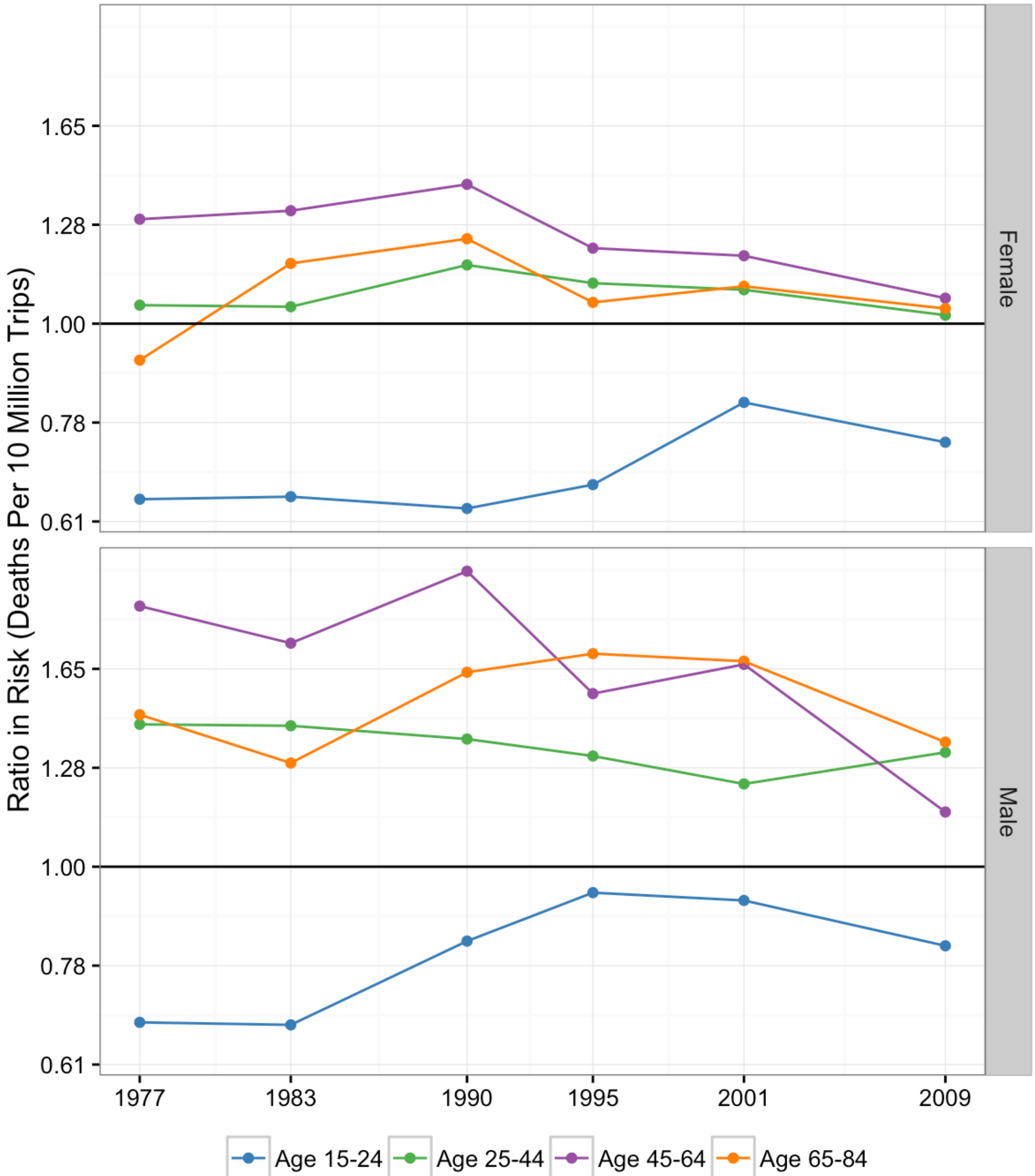


Figure 2.7 Age-Specific Black-White Ratio in Exposure by Gender Excluding Pedestrians Trips, 1977-2009

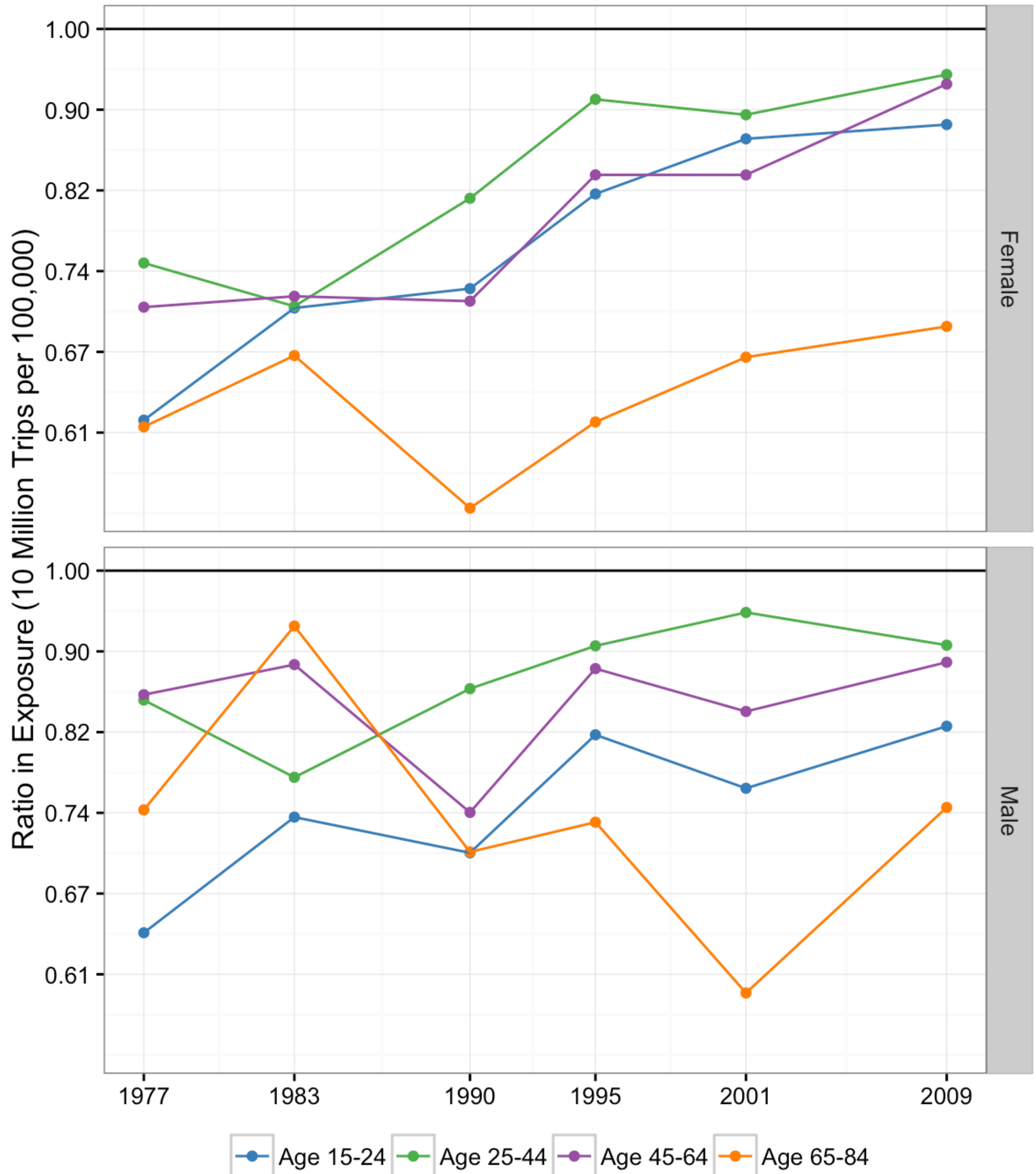
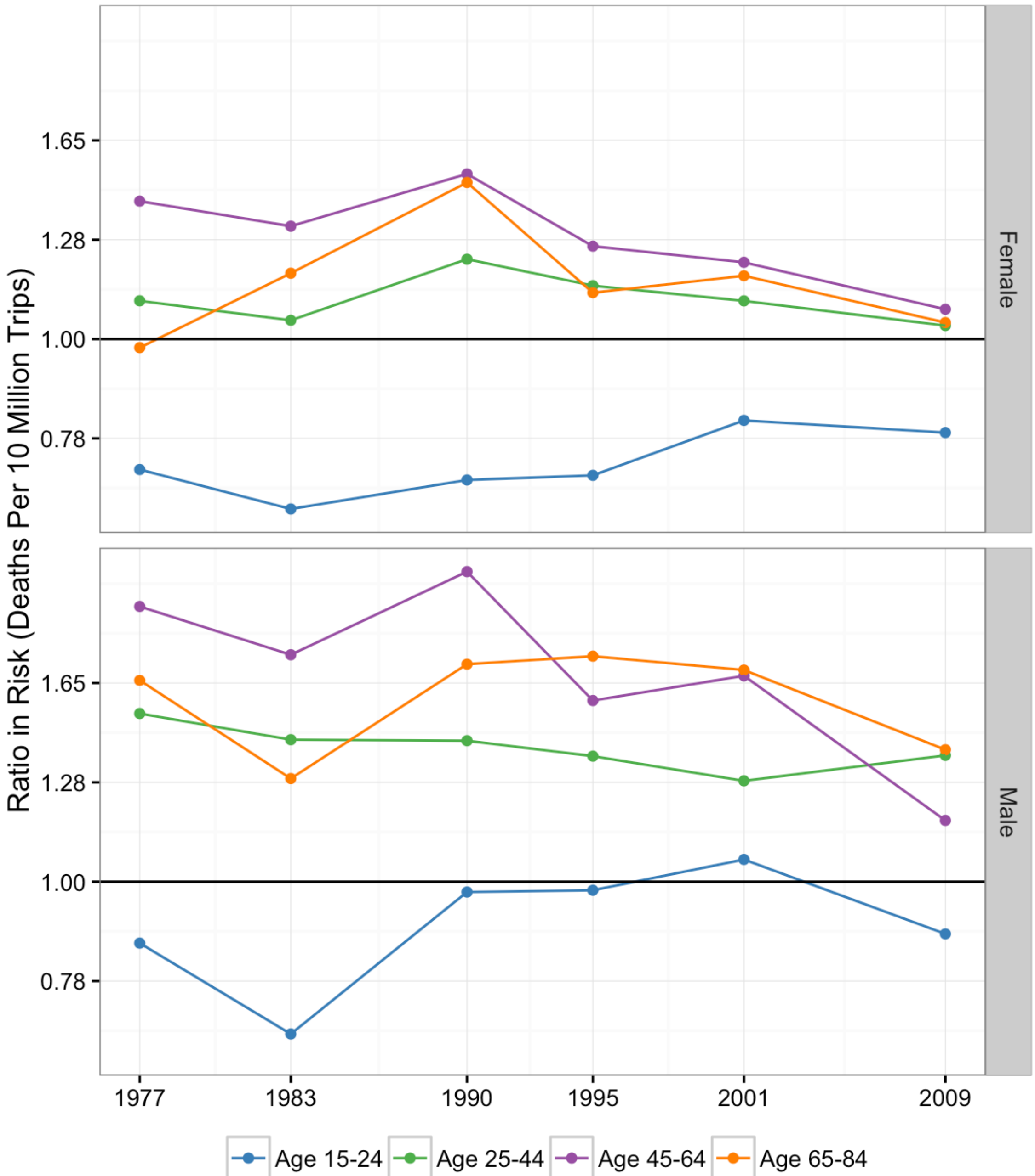


Figure 2.8 Age-Specific Black-White Ratio in Risk by Gender Excluding Pedestrians Trips, 1977-2009



CHAPTER 3

Black-White Differentials in Motor Vehicle Fatality Rates in the 2000s: A Demographic Decomposition

Introduction and Background

Health and mortality differences between non-Hispanic blacks and whites remain substantial in the United States. In 2010, the life expectancy of blacks lags behind that of whites by 3.8 years (Kochanek et al., 2013). Within the literature on black-white mortality differences, one outcome that has received little attention is motor vehicle crashes, which still accounts for over 30,000 deaths each year despite the progress made in recent decades (Kochanek et al., 2016). Deaths from motor vehicle crashes disproportionately affect the younger ages, particularly those between the ages of 15 and 24 (Kochanek et al., 2016). Thus, improving motor vehicle safety — with over half occurring below age 45 — holds the potential to make significant strides in increasing life expectancy (Kochanek et al., 2016).

Vital statistic reports on motor vehicle fatality rates for blacks and whites do not immediately cause alarm. In 2009, the age-adjusted motor vehicle fatality rate is 12.1 per 100,000 for whites and 12.0 per 100,000 for blacks (West and Naumann, 2013). However, age-standardized motor vehicle death rates do not capture the fact that transportation plays a vital and changing role throughout the life cycle. Children travel to school, working-age adults commute to work, and people of all ages participate in social and recreational activities outside of the home. Travel amount also changes throughout the life cycle. On average, the number of miles travelled per person rises as age increases, peaking at age 36 to 65, then precipitously falling for the over 65 age group (Santos et al., 2011).

Despite experiencing similar life course events, blacks and whites engage with transportation in different ways. For instance, whites are not only more likely to own vehicles compared to blacks but also own more valuable vehicles when they do (Lui et al., 2006). Blacks are also more likely than whites to use public transportation, which can be attributed to lower socioeconomic status and urban residence (Battelle, 2000; Pucher et al., 1998). These differences in mode choice, usage, and exposure between blacks and whites can play a role in contributing to differences in motor vehicle fatality rates at the population level.

Indeed, while on the surface fatality rates appear to be similar overall, age-specific motor vehicle death rates reveal stark differences at across the life cycle. Using data from the early 1980s, Baker et al. (1992) show a crossover in motor vehicle fatality rates between blacks and whites at age 30 to 35 and again at age 75 to 84. Whites have higher motor vehicle death rates in the teenage, young adult, and elderly ages compared to blacks, but blacks experience higher motor vehicle death rates in the adult ages. Black-white differences also emerge by type of motor vehicle death. Whites experience excess motor vehicle occupant deaths in the teenage and young adult ages compared to blacks (Baker et al., 1992). However, blacks, especially men, experience much higher death rates as pedestrians compared to whites. Less attention has been paid in recent years to examine whether these black-white patterns in motor vehicle fatalities have persisted while overall motor vehicle fatality rates have fallen nationally. There is recent indication that blacks remain disadvantaged in pedestrian deaths (Campos-Outcalt et al., 2003; Centers for Disease Control and Prevention, 2013) and whites remain disadvantaged in occupant deaths (Campos-Outcalt et al., 2003).

One missing link in the current discussion of black-white differences in motor vehicle death rates is the role of travel amount. Unlike diseases and illnesses, motor vehicle crashes can only occur to those who are exposed to travel outside of the home. Comparing death rates using the person-years of exposure as the denominator can obscure important differences in amount of travel between groups. Disaggregating motor vehicle death rates into amount of travel per person-year and the number of deaths per amount of travel can attribute these differences to exposure or risk of death. This demographic decomposition technique has been applied to the motor vehicle literature related to gender difference (Li et al., 1998; Zhu et al., 2013), older drivers (Dillinger et al., 2002), and macroeconomic conditions (Cotti and Tefft, 2013; French and Gumus, 2014; He, 2016).

A handful of studies have also incorporated travel amount to explain racial differences in motor vehicle fatalities. In a study of motor vehicle occupant deaths among adults, Braver (2003) finds blacks to be at higher risk of dying compared to whites given the same number of vehicle trips made. Similarly, Baker et al. (1998) find black children and teenagers with higher motor vehicle occupant death rate per billion vehicle-miles travelled compared to whites even when they show no disadvantage with population serving as the denominator.

Objectives

Previous papers have not painted a comprehensive picture of the black-white differences in motor vehicle fatality rates in recent years. The existing literature narrowly focuses on a particular age segment (Baker et al., 1998; Braver, 2003), motor vehicle mode (Baker et al., 1998; Braver, 2003), or geographic area (Campos-Outcalt et al., 2003). Vital statistics reports that include the whole age range at the population level fail to account for amount of travel (West and Naumann, 2013).

This paper answers the following research questions:

1) What are the differences in motor vehicle deaths for blacks and whites?

2) How do these differences vary by age?

3) To what extent does amount of travel account for these differences?

Answering these research questions is vital for coming up with policies to address black-white differences in motor vehicle deaths. Policy changes are less relevant if these differences can be fully explained by amount of travel; it is unlikely that governments will create policies to change driving amount since these are both perceived as a personal choice and often dictated by where people live and work. On the other hand, if there are racial differences that can be explained beyond amount of travel, then a policy solution is more feasible in addressing these mortality differences. In this paper I consider total motor vehicle fatalities and three major modes of travel: passenger vehicle occupants, motorcyclists, and pedestrians.

Data and Methods

Data

Data on detailed motor vehicle fatalities come from the Center for Disease Control and Prevention Wide-ranging OnLine Data for Epidemiologic Research (Centers for Disease Control and Prevention, 2016). To calculate motor vehicle death rates, I obtain number of motor vehicle deaths and person-years by race, age categories, and sex for total and each of the three major type of motor vehicle deaths aggregated for the 10-year period 2001 to 2010. I include only non-Hispanic blacks and whites and those who died between ages 5 and 84. During the study period there were 335,267 motor vehicle deaths. Table 3.1 shows the distribution of total motor vehicle deaths. The largest group, deaths are from passenger vehicle occupants, represent almost 40 percent of total motor vehicle deaths. Over 10 percent are from motorcyclists and pedestrians each. The remaining types of motor vehicle deaths make up about 10 percent, while about 30 percent are unspecified motor vehicle deaths.

Travel data come from the 2001 and 2009 years of the National Household Travel Survey (NHTS), a nationally representative that provides data on travel patterns in the United States. The NHTS was first conducted in 1969 (then known as the Nationwide Personal Transportation Surveys) and subsequently conducted every five to eight years. The survey includes information on the household, vehicles in the household, persons in the household, and travel information for persons in the household on an assigned travel day.

In order to align the travel and vital statistics data, I analyze detailed travel data for respondents between the ages of 5 and 84. The 2001 NHTS survey includes 160,758 persons of which 113,929 (92.5 percent) are non-Hispanic blacks and whites between the ages of 5 and 84 who made trips on their assigned travel day. In 2009, the sample size increases to 308,901 and 224,129 (72.5 percent) persons, respectively.[4]

In this chapter, I use person-miles travelled by different modes of travel as a proxy of travel amount.[5] To match the types of motor vehicle deaths, I examine travel by all modes, passenger vehicle occupants (including driver and non-driving occupants), walking, and motorcycle. In concordance with previous definitions, passenger vehicles include passenger cars, sports utility vehicles, vans, and pickup trucks (Beck et al., 2007).

Responses from the travel survey are weighted, provided by the NHTS, to generate annual estimates of travel amount by different population groups. First, I calculate miles travelled per person-year for each population group and mode of travel averaged from the 2001 and 2009 years of the NHTS. Then, I multiplied miles travelled per person-year by the number of person-years from the CDC WONDER database to

[4] These numbers are higher than the 2001 and 2009 NHTS samples used in chapter 2 because travel information for ages 5 to 14 is collected for these two recent surveys.
[5] Using number of trips made as the proxy for travel amount yields very similar results.

obtain amount of miles travelled for each age-sex group. These measures are used in the decomposition procedures discussed below.

In the NHTS, race and ethnicity is only collected at the household level from the main household respondent. The assumption is that each person in the household is of the same race as the main person who completes the survey for the household. In this chapter, I only include persons from households whose main respondent is of non-Hispanic black or white race. As mentioned in the discussion section of Chapter 2, I do not anticipate many interracial households.

Methods

At the core of this chapter is the decomposition of motor vehicle death rate into the product of two factors — risk and exposure (Equation 3.1). The risk component is the number of deaths for a unit of travel for each group, essentially the rate of death per amount of travel. The exposure component represents the rate of miles travelled for a particular age, sex, and race group in relation to the population size. This decomposition is performed for total motor vehicle deaths and the three major modes explored in this chapter.

$$\frac{Motor\ Vehicle\ Deaths}{100{,}000\ person\ years} = \frac{Motor\ Vehicle\ Deaths}{100\ Million\ Miles\ Travelled} \times \frac{100\ Million\ Miles\ Travelled}{100{,}000\ person\ years}$$

(Eq. 3.1)

I begin by presenting the age-standardized motor vehicle death rates and its decomposed factors by race, sex, and mode for ages 5 to 84 during the study period. The death rates are standardized using 2000 U.S. population in the five broad age categories that will be used for the rest of the chapter (Day, 1996). I then plot the age-specific motor vehicle death rates to illustrate the patterns in black-white differences across the life cycle. Next, I show descriptive, age-specific results of each component can give a sense of the relative size of each factor between blacks and whites.

I then follow Das Gupta's (1993) decomposition-standardization methodology to quantify how much of the black-white difference in motor vehicle death rates for a particular age and sex group and mode is due to risk and exposure. Equation 3.2 shows that the total effect, which is the difference between black and white motor vehicle death rate, can be decomposed into the risk effect and the exposure effect. The risk effect is the difference between exposure-standardized black and white risk rates (Equation 3.3). Similarly, the exposure effect is the difference between risk-standardized black and white exposure rates (Equation 3.4). In the results below, I will show the contribution of the risk and exposure component by age, sex, and mode.

$$Total\ Effect = Motor\ Vehicle\ Death\ Rate_{black} - Motor\ Vehicle\ Death\ Rate_{white}$$

(Eq. 3.2)

$$Risk\ Effect = \frac{Exposure\ Rate_{black} + Exposure\ Rate_{white}}{2} \times (Risk\ Rate_{black} - Risk\ Rate_{white})$$

(Eq. 3.3)

$$Exposure\ Effect = \frac{Risk\ Rate_{black} + Risk\ Rate_{white}}{2} \times (Exposure\ Rate_{black} - Exposure\ Rate_{white})$$

(Eq. 3.4)

Results

Age-Standardized

Table 3.1 presents the age-standardized rates of each component in Equation 3.1 for blacks and whites by gender and type of motor vehicle fatality. The black-white difference in death rates vary by gender and type of death. Overall, black women experience lower total motor vehicle death rates compared to whites during the study period. The black advantage among women persists for passenger vehicle occupants and motorcyclists, but not as pedestrians. Meanwhile, black men experience a disadvantage in total motor vehicle fatality compared to white men. Black men also experience higher motor vehicle death rates as passenger vehicle occupants and pedestrians, but not as motorcyclists, compared to white men. Both black men and women are consistently advantaged in motorcycle death rates and disadvantaged in pedestrian death rates compared to their white counterparts.

Looking at the exposure components, I find that blacks are travelling fewer miles compared to whites in every mode except for as pedestrians. On the other hand, blacks are experiencing higher risk compared to whites in every mode of death. These results suggest that blacks benefit from lower exposure compared to whites but are more disadvantaged in the risk component.

Age-Specific Death Rates

I now show the age-specific motor vehicle death rates in 5-year age groups in order to reveal patterns at different points of the life cycle. Figure 3.1 and Figure 3.2 show the age-specific patterns in motor vehicle deaths for blacks and whites by mode for females and males, respectively. Overall, whites experience a relative disadvantage (or smaller advantage) in motor vehicle death rates at young adult ages while blacks tend to experience a relative disadvantage as prime age adults. The first rows of Figure 3.1 and Figure 3.2 show that total motor vehicle fatality rates peak during the teenage and young adult ages before declining and flattening in adulthood and rising again in the older adult ages. For women, whites have higher rates of death during the teenage and young adult ages, from 15 to 24, compared to blacks. In particular, total motor vehicle fatality rates for whites is doubled that of blacks at ages 15 to 19. Motor vehicle fatality rates for black and white women remain similar from ages 25 to 59. At age 60 and over, white women's motor vehicle fatality rates surpass that of blacks with the difference growing larger as age increases.

Moving to the top of Figure 3.2 for men, I find at the youngest driving ages, white men exhibit higher death rates compared to black men. Although this pattern is similar to the that for women, the male black-white difference in the teenage years is smaller. A mortality crossover occurs after age 25 when black men start to experience higher motor vehicle death rates compared to white men. Later, at ages 70 to 79, the black-white difference begins to diminish before white men's death rates surpass those of black men at ages 80 to 84.

The patterns for passenger vehicle occupant deaths shown in the second row largely mimic those in the first row. Among both sexes, white teenagers and young adults experience higher passenger vehicle occupant death rates compared to their black counterparts. Most dramatically, in the teenage years from ages 15 to 19, white death rates is about twice that of black death rates. During the adult ages, white men exhibit higher death rates than black men. A small white disadvantage among women emerges in certain, but not all, adult age groups. Similar to the top row, in the older adult ages, white women start to experience higher passenger vehicle occupant death rates from age 60 with the difference growing larger into the older adult ages. For older men, the white disadvantage does not appear until age 80 to 84 just as it was shown in the first row of this figure.

The third rows in Figure 3.1 and Figure 3.2 show the age-specific motorcycle death patterns for blacks and whites. Motorcycle death rates peak at age 30 to 34 for black women and 40 to 44 for white women. Overall, white women experience excess motorcycle death rate compared to black women at all ages, although the rates are lower than that of men. Men's motorcycle death rates exhibit several racial crossovers. Between ages 15 and 24, whites have higher motorcycle death rates compared to blacks. However, between ages 25 to 39, black men's motorcycle death rates peak and remain higher than those of whites. At ages 40 and over, white men again experience higher motorcycle death rates compared to blacks. Motorcycle death rates for blacks continue to decline while white men's motorcycle death rates peak again in the 40s before falling.

The bottom row of Figure 3.1 and Figure 3.2 describe age-specific pedestrian death rates for blacks and whites. For whites, pedestrian death rates steadily climb as age increases, with a precipitous increase after age 60. Black pedestrian death rate patterns are similar to those of whites but experience a first peak at around age 45 to 50. In terms of the differentials between blacks and whites, black men experience higher pedestrian death rate at every age compared to white men. Black women also experience higher death rates as pedestrians at all ages except above over age 70 when white women's death rates exceed those of blacks.

Risk and Exposure Factors

In Figure 3.3 to Figure 3.6, I plot motor vehicle fatality rates and its two decomposed products, risk and exposure factors, for blacks and whites by sex. For analysis from here on forward, I use five broader age groups — ages 5 to 14, ages 15 to 24, ages 25 to 44, ages 45 to 64, and age 65 to 84 — to reflect distinct life cycle groups (e.g. ages 15 to 24 represent young adults and teenagers who are often new drivers). The overall trend here is that the risk component is often higher for blacks while the exposure component is generally higher for whites.

Figure 3.3 top row shows the total motor vehicle fatality rates in the five age groups. For women, whites have higher motor vehicle fatality rates in ages 15 to 24 and ages 65 to 84, but black and white women experience similar death rates in the other three age groups. Meanwhile, black men experience higher total motor vehicle fatality rates than white men in all age groups except for the 15- to 24-year-old group. The second row shows that blacks have higher risk of dying in every age-sex group except for men ages 15 to 24. Meanwhile, the bottom row of Figure 3.3 shows that whites are travelling more miles than blacks in every age-sex group. Despite lower overall travel rates, black men and women experience higher or equal amounts of total motor vehicle death rates during the adult ages. During the teenage and young adult ages when whites are dying at higher rates, the decomposition shows that it is due to higher exposure rather than higher risk among whites.

Figure 3.4 now moves onto passenger vehicle occupant deaths. The first row shows that the death rates between blacks and whites exhibit a similar pattern to that of total motor vehicle fatality rates in Figure 3.3. The second row shows that blacks have higher risk of dying given a fixed amount of miles travelled compared to whites in all age and sex groups except for ages 15 to 24. Black men ages 45 and over especially experience much greater risk compared to their white counterparts. As with Figure 3.3, the bottom row in Figure 3.4 shows that whites are travelling many more miles than blacks in passenger vehicles. The only exception is for men ages 25 to 44 where the black-white travel rate is more equitable. Despite lower travel rates as passenger vehicle occupants, black men are experiencing these higher motor vehicle death rates during the adult ages. Again, when whites are experiencing higher death rates as teenagers, young adults and elderly adults (for women), higher exposure appears to play a larger role in explaining the white disadvantage.

Figure 3.5 explores the factors for motorcycle deaths. The top row shows that whites experience higher motorcycle death rates in all age and sex groups except for men ages 25 to 44. Due to small sample sizes of motorcycle travel in the NHTS, risk and exposure factors are not available for black men ages 5 to 14 and black women at all ages except 25 to 44. Where data is available, black women and and older black men are at a much higher risk of dying from motorcycle deaths given a fixed amount of travel compared to whites. Figure 3.5 bottom row indicates that black and white men travel via motorcycle about the same amount from 15 to 44, but white men travel much more than black men at ages 45 and up.

Pedestrian death patterns for blacks and whites are displayed in Figure 3.6. The top row shows that pedestrian death rate is higher among blacks than whites in every age and sex group except for women age 65 and over. Moving onto row two, I find risk of dying per mile of travel is higher for blacks than whites in all age and sex groups except for men ages 15 to 24. The black disadvantage in pedestrian risk and death rate is especially drastic for men age 45 and over. In terms of exposure, black men are walking more than whites in younger ages, but this difference diminishes in the adult ages and reverses at ages 45 and over. Black women walk more than white women as children and at ages 45 to 64. In the other age groups, black and white women walk about the same amount. Higher walking among blacks in younger ages is likely to explain their higher pedestrian death rates. However, risk appears to play a bigger role in explaining higher black pedestrian death rates in older ages, especially for men.

Decomposition of Total Effects

After describing the size of the risk and exposure factors, I now show the results for the decomposition of total effects for blacks relative to whites. As explained earlier, the total effect is the difference in motor vehicle fatality rates between blacks and whites. Table 3.3 through Table 3.6 show the total effect decomposed into risk and exposure and the corresponding percentages attributed to risk and exposure effects. As stipulated in Equation 3.2, the risk and exposure effects add up to the total effect. The interpretation of a positive effect means that it is contributing to the relative disadvantage for blacks, while a negative effect means that it is contributing to an advantage for blacks.

For ease of interpretation, Figure 3.7 plots the risk (red bar) and exposure (green bar) effects by sex and age groups for specific modes of motor vehicle deaths. Across the board, the risk effect is positive for almost all age and sex groups, meaning that the risk component almost always contributes to a disadvantage for blacks compared to whites. The risk effect grows larger for older black male age groups in all modes of travel. There are a few notable exceptions to the positive risk effect. In ages 15 to 24 for men in all types of motor vehicle deaths and for women in passenger vehicle occupant deaths, the risk effect is revealed to be negative.

With the major exception of pedestrian deaths, the exposure effect almost always contributes to an advantage for blacks as shown by the negative green bars. For total and passenger vehicle occupants, low travel exposure is particularly advantageous for black women and men ages 15 to 24 and 65 to 84 and also for men ages 45 to 64. The exposure effect exhibits anomalies in pedestrian deaths shown in the bottom row of Figure 3.7. For women at all ages except for the oldest ages and for men in ages 5 to 44, the exposure effect is positive.

Discussion and Conclusions

The main objectives of the paper are to provide a demographic analysis of the black-white differences in motor vehicle fatality rates across the life course and to evaluate the role of exposure in explaining these differences. On the surface, age-standardized rates do not yield large differences in total motor vehicle death rates between blacks and whites. I examine age-specific motor vehicle death rates in order to uncover patterns across the life cycle that may be obscured by age-standardized rates.

Indeed, I identify black-white mortality crossovers in passenger vehicle occupant deaths. In ages 15 to 24 and older adult ages, whites of both sexes are experiencing higher rates of passenger vehicle occupant deaths. At adults ages 25 and over, black men encounter higher passenger vehicle occupant fatality rates compared to white men. In motorcycle deaths, there is a similar pattern of mortality crossover where white men exhibit higher death rates in teenage years and adult ages 40 and over but not in the early adulthood ages. Notably, the pedestrian disadvantage among black men and women persists in all age groups except for women ages 75 and over. The black-white difference in pedestrian death rates widens in the middle adult ages for those around 45 to 54 years old. Although motor vehicle fatality rates have fallen over the past several decades, the age-specific patterns between blacks and whites from the 2000s look similar to Baker et al.'s (1992) chapter illustrating these trends from the 1980s.

Noting these key differences, I then explore the role that travel amount plays in explaining these differences. Overall, I find that blacks are traveling fewer miles than whites, which should lower their relative death rates. However, blacks are at much higher risk of dying when they do travel that this disadvantage often eliminates their advantage in low exposure rate. In cases when whites have higher death rates in the teenage, young adult, and older ages, their higher exposure to miles travelled contributes to this difference. When blacks are disadvantaged, it is almost always due to higher risk per amount of travel. In fact, if blacks were exposed to the same levels of miles travelled as whites, the black-white difference in motor vehicle death rates would be even greater in most cases. One major exception is for black children of both sexes and black men ages 15 to 24 when their higher pedestrian death rates are attributable to higher walking rates compared to whites. My findings echo similar conclusions to Baker et al.'s (1998) study but extends beyond the population of black children and teenagers in vehicle occupant deaths.

These results offer different explanations for why whites or blacks have higher motor vehicle fatality rates at various period of the life course. Higher passenger vehicle occupant death rates among whites in the teenage and young adult ages are due to more miles travelled in these vehicles. This points to greater access to vehicles for white teenagers at the transition to legal driving age. Another explanation may be related to the racial divide in geographic residence. Blacks are more likely to live in urban areas better served by public transportation or walking rather than in car-dependent rural and suburban areas.

For blacks, the results suggest that higher deaths per mile of travel, especially for men, contributes to their relative disadvantage in motor vehicle death rates in almost all age groups. This finding is disconcerting and raises questions about why blacks experience higher risk of motor vehicle deaths. One possible explanation is that blacks have lower socioeconomic status, which is associated with harmful behaviors like lack of seatbelt use and driving while intoxicated (Braver, 2003). However, it is important to explore factors outside of individual behaviors so as not to engage in a rhetoric where individuals are blamed for actions that directly lead to their deaths. Outside of the individual, another explanation is that black neighborhoods have worse infrastructure that can also play a role in elevating risk of motor vehicle deaths. As mentioned in Chapter 2, the Federal Aid Highway Act of 1956 allocated $25 billion to interstate highway construction over the next two decades (Lewis, 2013). Many scholars have argued that highways were purposefully built in urban, often black, neighborhoods where residents have less political agency to protest (Davies, 1975). As a result, highways replaced green spaces, created greater neighborhood disorder, and led to de-investment in these neighborhood (Kay, 1997). These changes in infrastructure could lead to more dangerous conditions for driving and walking. In another study, the authors find more liquor stores in black neighborhoods even after controlling for socioeconomic status of the area (LaVeist and Wallace, 2000). It is possible that these environmental factors can negatively influence motor vehicle crash outcomes in addition to individual behaviors. Finally, racial discrimination can potentially play a role in creating this disparity. A recent paper finds drivers are less likely to stop for black pedestrians compared to whites (Coughenour et al., 2017). Conceivably, this type of discriminatory behavior can lead to higher pedestrian death rate for blacks.

A major exception to the higher risk among blacks is for the 15 to 24 age group where blacks' relative lower risk contributes to their relative advantage in motor vehicle death rates. This finding does not align with the results of an earlier study from Baker et al. (1998), which finds higher risk of death per miles travelled among blacks compared to whites. One explanation for this notable trend could be related to black and white differences in behavioral factors. A recent study finds white high school students over 1.5 times more likely to engage in texting or emailing while driving compared to black students (Olsen et al., 2013). Moreover, they find that students who engage in this behavior are more likely to engage in other risky behaviors such as not using their seatbelt and drunk driving. Future studies should start by examining patterns of behaviors for black and white teenage drivers in order to identify points of intervention to mitigate higher risk among white teenagers.

The results presented in this chapter provides directions for policy implications that aims to reduce racial disparities in motor vehicle deaths. At the young adult ages, whites are experiencing higher motor vehicle fatality rates largely through more miles travelled compared to blacks. Thus, the policy implication would be to examine why white young adults are travelling more and whether this disparity can be reduced. At the same time, if black teenagers and young adults are forced to experience limited mobility, then perhaps new policy should be to targeted toward increasing access to safe transportation for this group. For those between 25 and 64, policy should be directed to lower the risk of motor vehicle deaths per unit of travel for blacks, especially black men. Future research should look more closely into the high risk for blacks and weigh the relevance of individual and contextual factors.

A few limitations of this study should be noted. First, due to data constraints I do not account for differences in socioeconomic status between blacks and whites. As the previous chapter has shown, socioeconomic status can account for the higher risk of motor vehicle deaths among black adults. Future studies can expand on this current work by controlling for differences in socioeconomic status, such as education or poverty, in all age groups. The CDC data also do not include specific behaviors that led to the crash. As a result, I am not able to identify crashes that resulted from speeding or drunk driving or lack of seatbelt use, which would provide a clearer direction for policy. However, even if these data are available, researchers should be weary of how they are collected. Are these data collected for every crash or are minorities or crashes in poorer neighborhoods more likely to elicit collection of information on risky behaviors? Finally, the population estimates provided by the CDC, which is used as the population denominator and in the calculation of travel amount, include institutionalized and imprisoned populations. Because motor vehicle deaths are very unlikely to occur for those in prisons, this issue would lead to an underestimate of the risk component if the travel amount were to only reflected those who are not incarcerated. Since black men are disproportionally incarcerated, the risk component of this group could be higher than they already are, thus further increasing the importance of risk in driving the black disadvantage in motor vehicle deaths.

This work builds on the previous chapter which finds the black-white difference in motor vehicle deaths has substantially narrowed over the past several decades. In this chapter, I focus on the decade of the 2000s to see what differences remain and how exposure or risk can account for these differences. The findings reveal substantial disadvantage among blacks — particularly among men. Despite travelling less than whites are a whole, blacks are experiencing higher motor vehicle death rates because they are at greater risk of dying when they do travel. Future research should identify mechanisms that explain the higher risk among blacks so that policies can be implemented to eliminate these disparities.

Table 3.1 Motor Vehicle Deaths by Type, 2001-2010

Type of MV deaths	Number (percent)
Total	335,267 (100%)
Passenger Vehicle	128,196 (38.2%)
Motorcycle	37,503 (11.2%)
Pedestrian	35,261 (10.5%)
Others	134,307 (40.1%)

Source: CDC 2001-2010

Table 3.2 Age-Standardized Death Rate, Exposure, and Risk by Mode, Race, and Sex, 2001-2010

		Total Motor Vehicle	Passenger Vehicle Occupant	Motorcyclist	Pedestrian
Female					
Death Rate	Black	7.77	3.34	0.17	1.37
	White	9.25	4.15	0.57	0.87
	% Difference	-16.03	-19.57	-69.39	57.76
Exposure	Black	10.05	8.89	0.00	0.10
	White	13.65	12.21	0.01	0.09
	% Difference	-26.37	-27.24	-96.20	15.74
Risk	Black	0.83	0.40	397.03	14.19
	White	0.69	0.35	49.29	10.27
	% Difference	19.33	15.24	705.52	38.14
Male					
Death Rate	Black	22.83	7.99	2.90	3.96
	White	21.62	7.75	3.83	1.95
	% Difference	5.59	3.06	-24.08	103.12
Exposure	Black	13.69	11.66	0.05	0.11
	White	16.76	13.97	0.09	0.09
	% Difference	-18.29	-16.58	-48.45	28.40
Risk	Black	1.70	0.70	235.14	41.29
	White	1.31	0.56	54.58	21.93
	% Difference	29.46	25.86	330.80	88.30

Source: CDC 2001-2010; NHTS 2001, 2009

Note: Only ages 25-44 included for female motorcyclist deaths; all men except for ages 5-14 included for male motorcyclist deaths

Table 3.3 Decomposition of Total MV Death Rates into Risk and Exposure Effects

Age	Total Effect	Risk Effect	Exposure Effect	% due to Risk	% due to Exposure
Female					
5-14	0.17	1.28	-1.11	758.22	-658.22
15-24	-5.85	0.09	-5.94	-1.52	101.52
25-44	-0.59	0.94	-1.53	-158.54	258.54
45-64	0.03	2.59	-2.56	8521.37	-8421.37
65-84	-3.62	2.38	-6.00	-65.70	165.70
Male					
5-14	0.46	1.59	-1.13	346.94	-246.94
15-24	-9.77	-1.98	-7.79	20.24	79.76
25-44	4.94	6.72	-1.78	136.06	-36.06
45-64	3.61	10.29	-6.68	285.12	-185.12
65-84	1.08	11.63	-10.55	1075.27	-975.27

Source: CDC 2001-2010; NHTS 2001, 2009

Table 3.4 Decomposition of Passenger Vehicle Occupants MV Death Rates into Risk and Exposure Effects

Age	Total Effect	Risk Effect	Exposure Effect	% due to Risk	% due to Exposure
			Female		
5-14	0.02	0.50	-0.48	2295.45	-2195.45
15-24	-3.16	-0.17	-2.99	5.48	94.52
25-44	-0.21	0.57	-0.78	-274.62	374.62
45-64	-0.15	0.84	-0.99	-563.31	663.31
65-84	-1.92	0.69	-2.61	-35.86	135.86
			Male		
5-14	0.01	0.17	-0.15	1285.53	-1185.53
15-24	-4.35	-0.82	-3.53	18.93	81.07
25-44	1.55	1.66	-0.11	107.30	-7.30
45-64	1.51	3.98	-2.47	264.05	-164.05
65-84	0.21	4.15	-3.94	2001.22	-1901.22

Source: CDC 2001-2010; NHTS 2001, 2009

Table 3.5 Decomposition of Motorcycle MV Death Rates into Risk and Exposure Effects

Age	Total Effect	Risk Effect	Exposure Effect	% due to Risk	% due to Exposure
Female					
25-44	-0.39	2.08	-2.48	-527.72	627.72
Male					
15-24	-1.78	-0.44	-1.34	24.63	75.37
25-44	0.86	0.70	0.16	81.89	18.11
45-64	-2.82	25.41	-28.24	-900.97	1000.97
65-84	-0.82	5.83	-6.65	-710.25	810.25

Source: CDC 2001-2010; NHTS 2001, 2009

Table 3.6 Decomposition of Pedestrian MV Death Rates into Risk and Exposure Effects

Age	Total Effect	Risk Effect	Exposure Effect	% due to Risk	% due to Exposure
			Female		
5-14	0.42	0.13	0.29	31.81	68.19
15-24	0.37	0.33	0.04	90.35	9.65
25-44	0.56	0.56	0.01	98.58	1.42
45-64	0.83	0.52	0.31	62.46	37.54
65-84	-0.05	0.11	-0.16	-235.26	335.26
			Male		
5-14	0.75	0.12	0.64	15.32	84.68
15-24	0.59	-0.6	1.18	-101.81	201.81
25-44	1.86	1.09	0.77	58.4	41.6
45-64	3.65	4.21	-0.56	115.2	-15.2
65-84	2.57	3.49	-0.92	135.9	-35.9

Source: CDC 2001-2010; NHTS 2001, 2009

Figure 3.1 Female Black and White Age-Specific Death Rates for Motor Vehicle Deaths by Mode, 2001 to 2010
Note: Y-axis differs

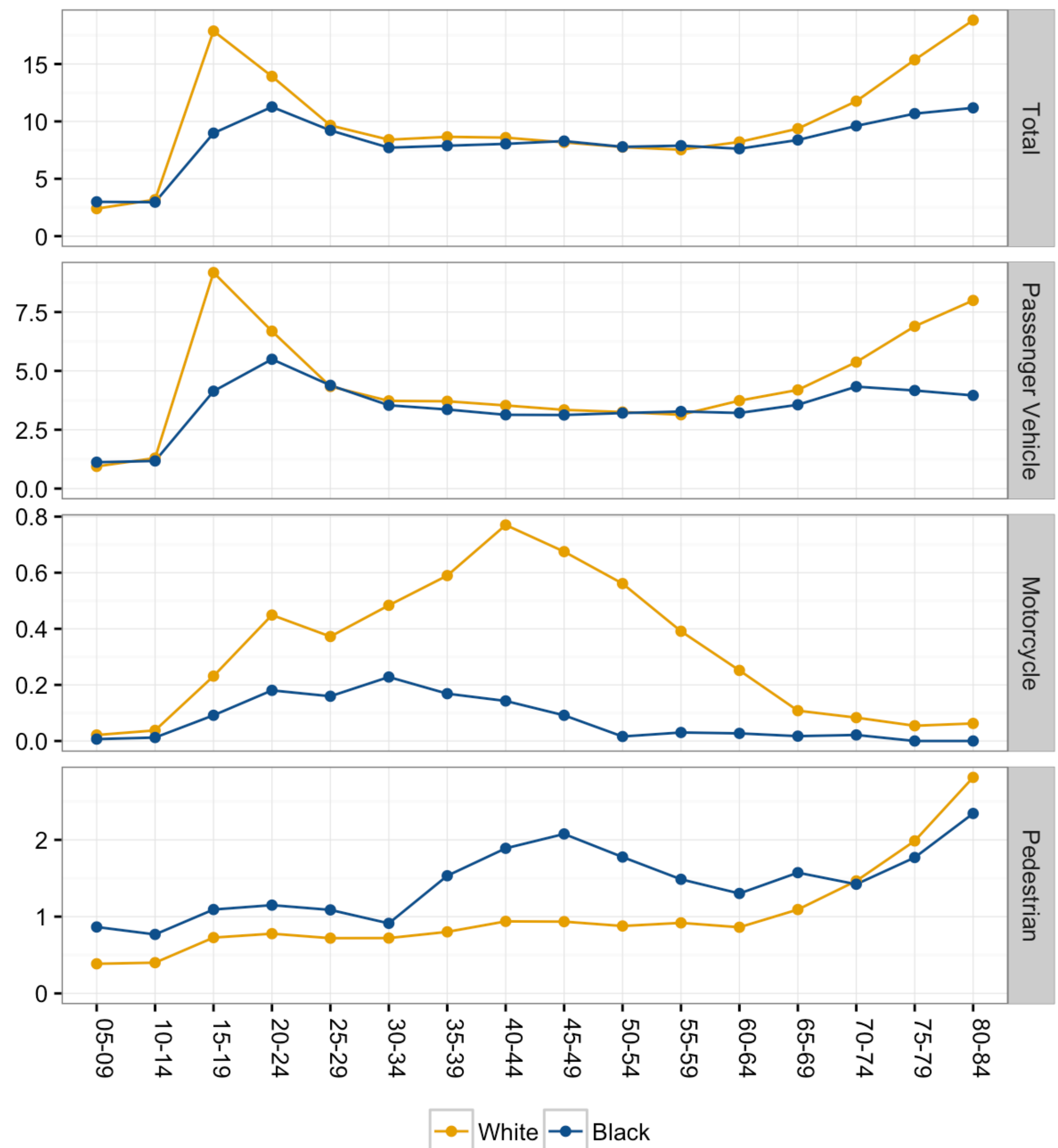


Figure 3.2 Male Black and White Age-Specific Death Rates for Motor Vehicle Deaths by Mode, 2001 to 2010
Note: Y-axis differs

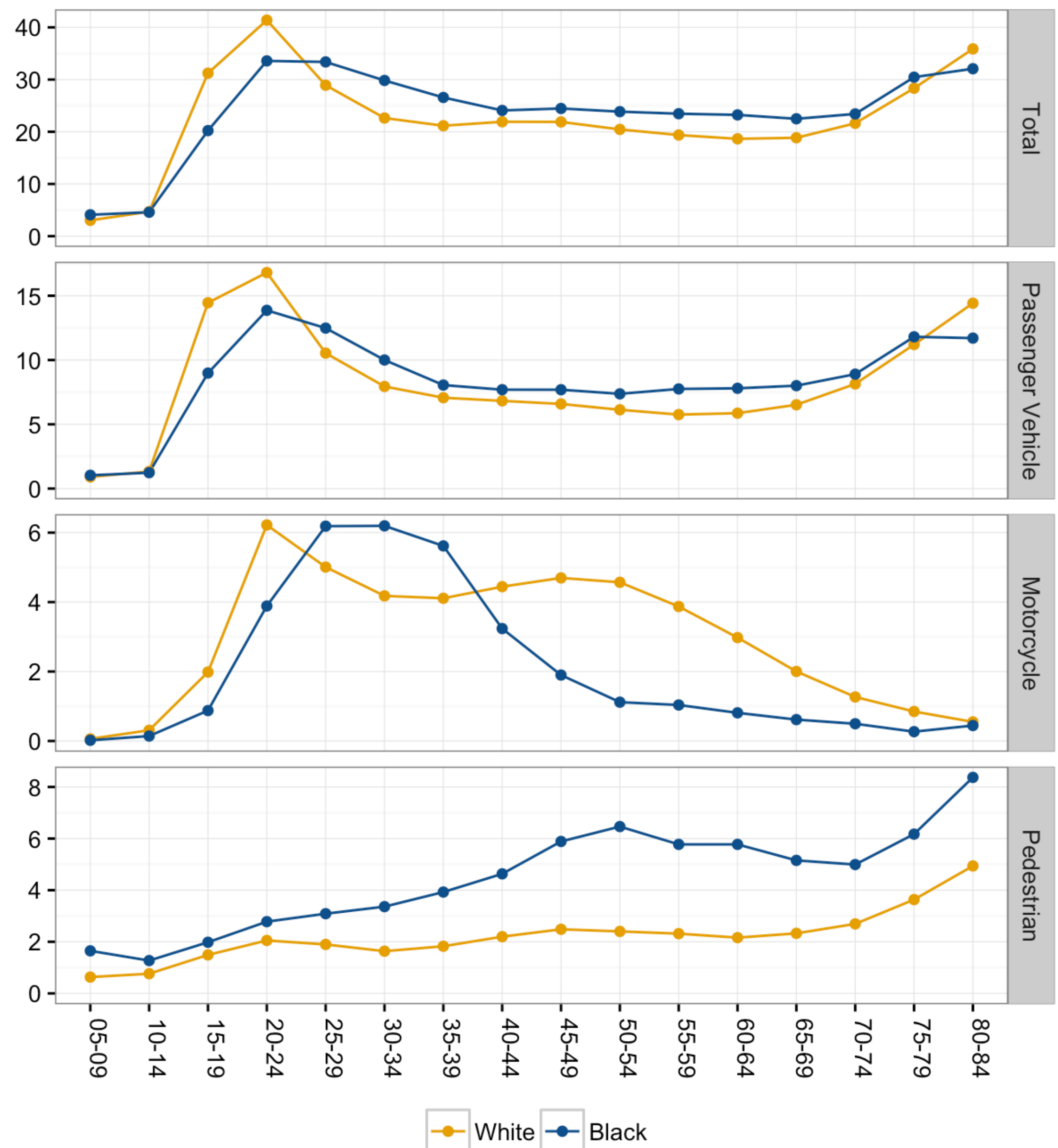


Figure 3.3 Total MV Death Rate, Risk Rate, and Exposure Rate by Race, Sex and Age, 2001 to 2010
Death Rate = Deaths per 100,000 person-years
Risk Rate = Deaths per 100 million Miles Travelled
Exposure Rate = 100 million Miles Travelled per 100,000 Person-Years
Note: Y-axis differs

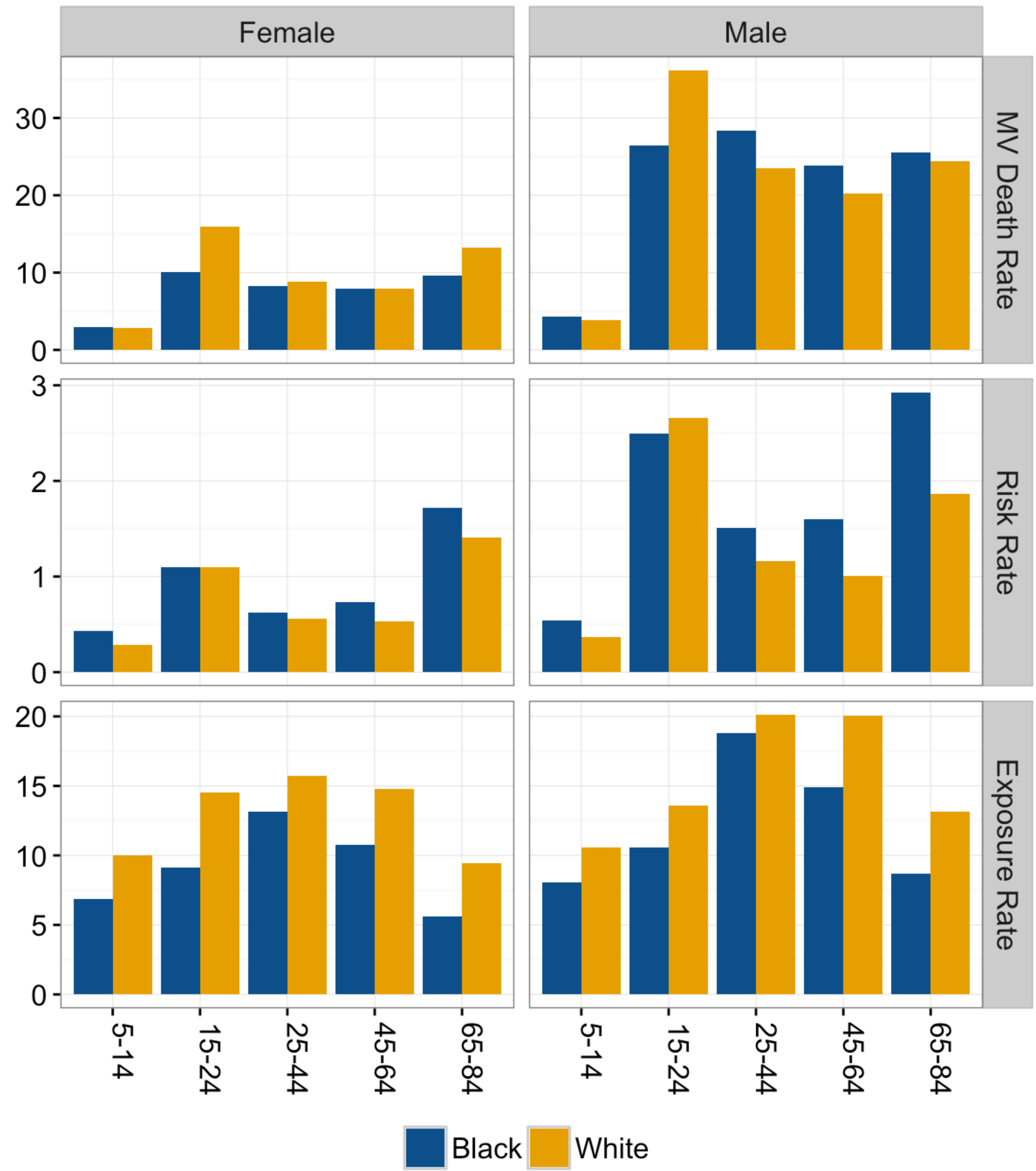


Figure 3.4 Passenger Vehicle MV Death Rate, Risk Rate, and Exposure Rate by Race, Sex and Age, 2001 to 2010
Death Rate = Deaths per 100,000 person-years
Risk Rate = Deaths per 100 million Miles Travelled
Exposure Rate = 100 million Miles Travelled per 100,000 Person-Years
Note: Y-axis differs

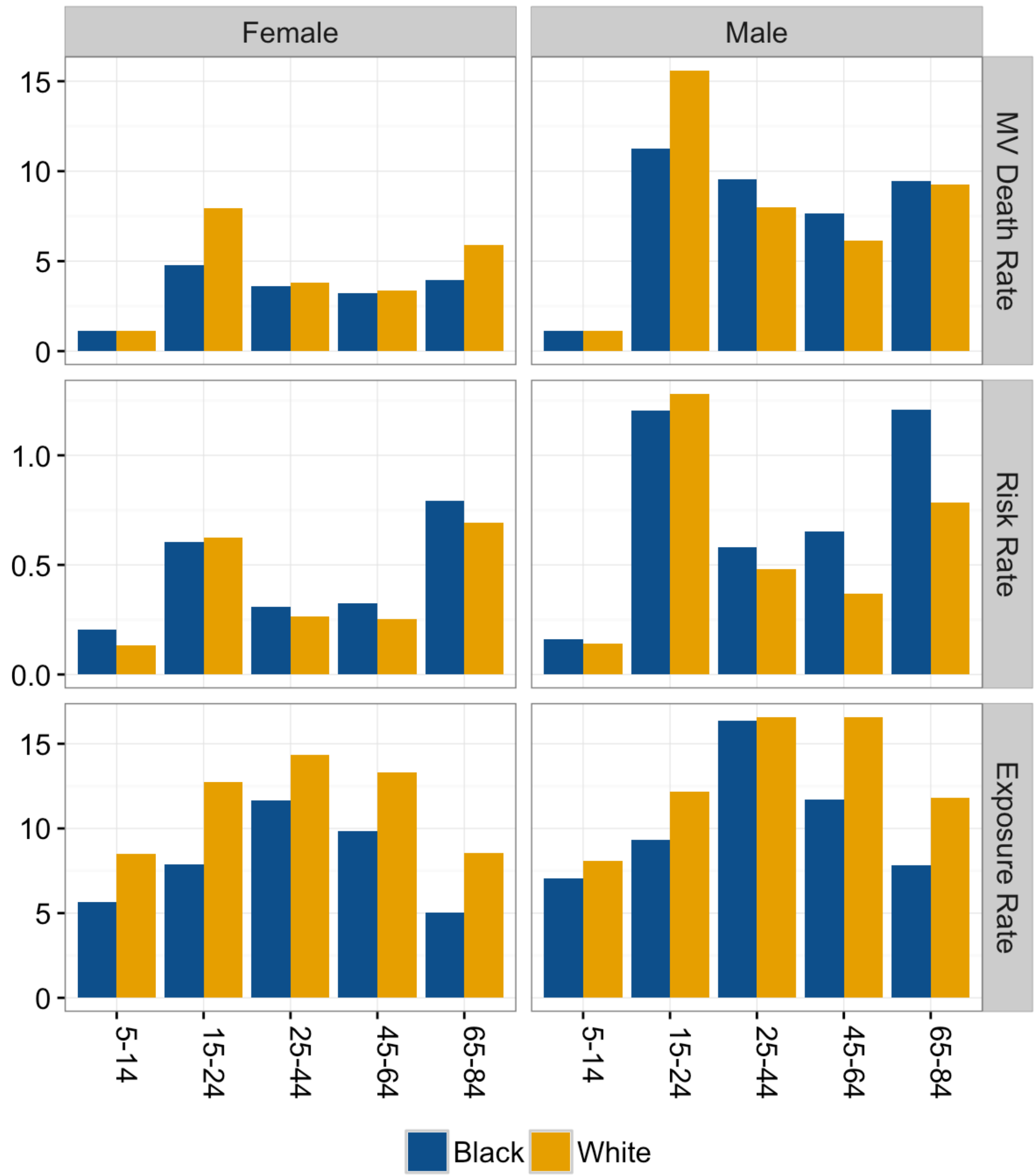


Figure 3.5 Motorcycle MV Death Rate, Risk Rate, and Exposure Rate by Race, Sex and Age, 2001 to 2010
Death Rate = Deaths per 100,000 person-years
Risk Rate = Deaths per 100 million Miles Travelled
Exposure Rate = 100 million Miles Travelled per 100,000 Person-Years
Note: Y-axis differs; Black risk and exposure rates only available for females ages 25-44 and not available for black males ages 5-14.

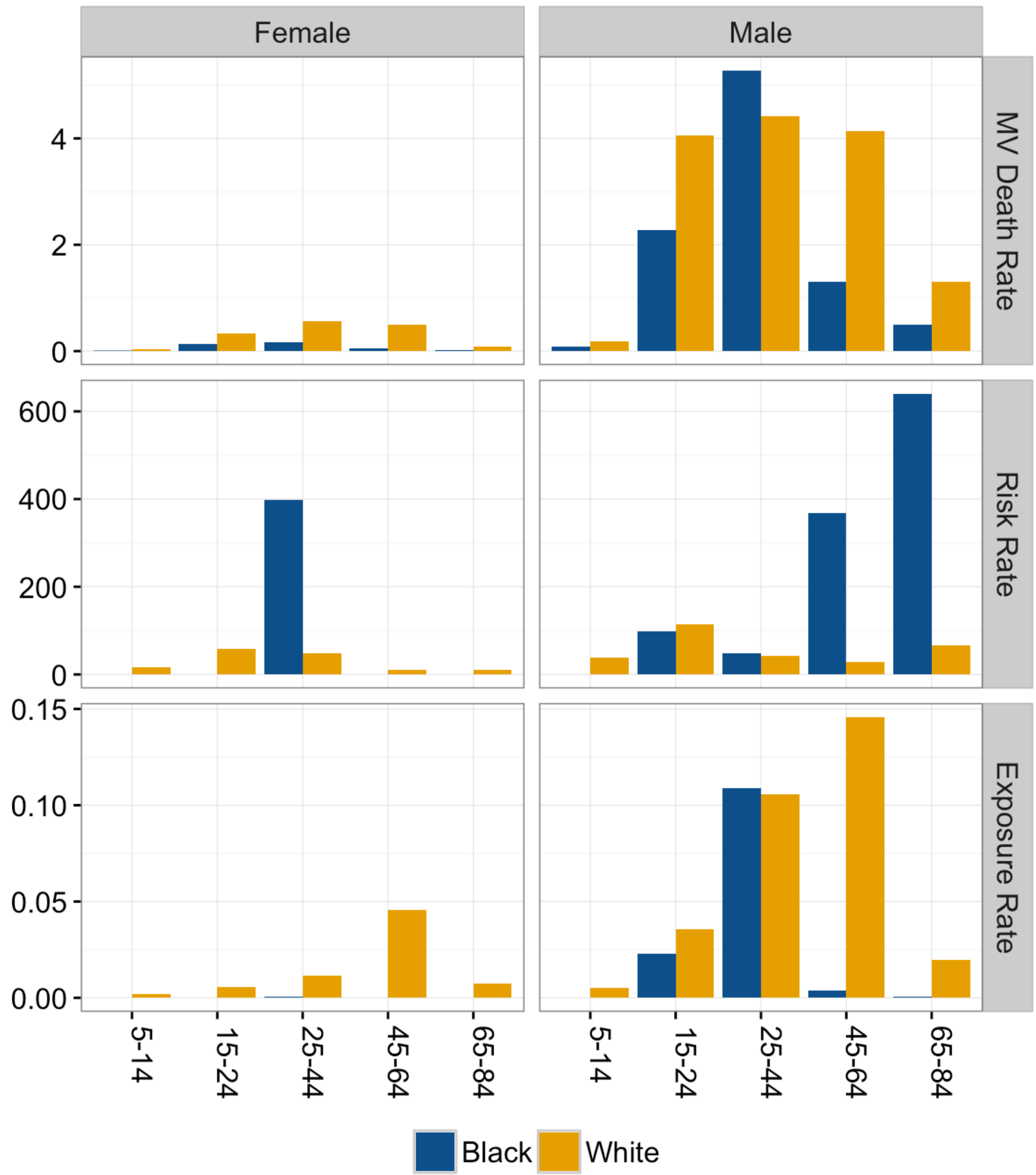


Figure 3.6 Pedestrian MV Death Rate, Risk Rate, and Exposure Rate by Race, Sex and Age, 2001 to 2010
Death Rate = Deaths per 100,000 person-years
Risk Rate = Deaths per 100 million Miles Travelled
Exposure Rate = 100 million Miles Travelled per 100,000 Person-Years
Note: Y-axis differs

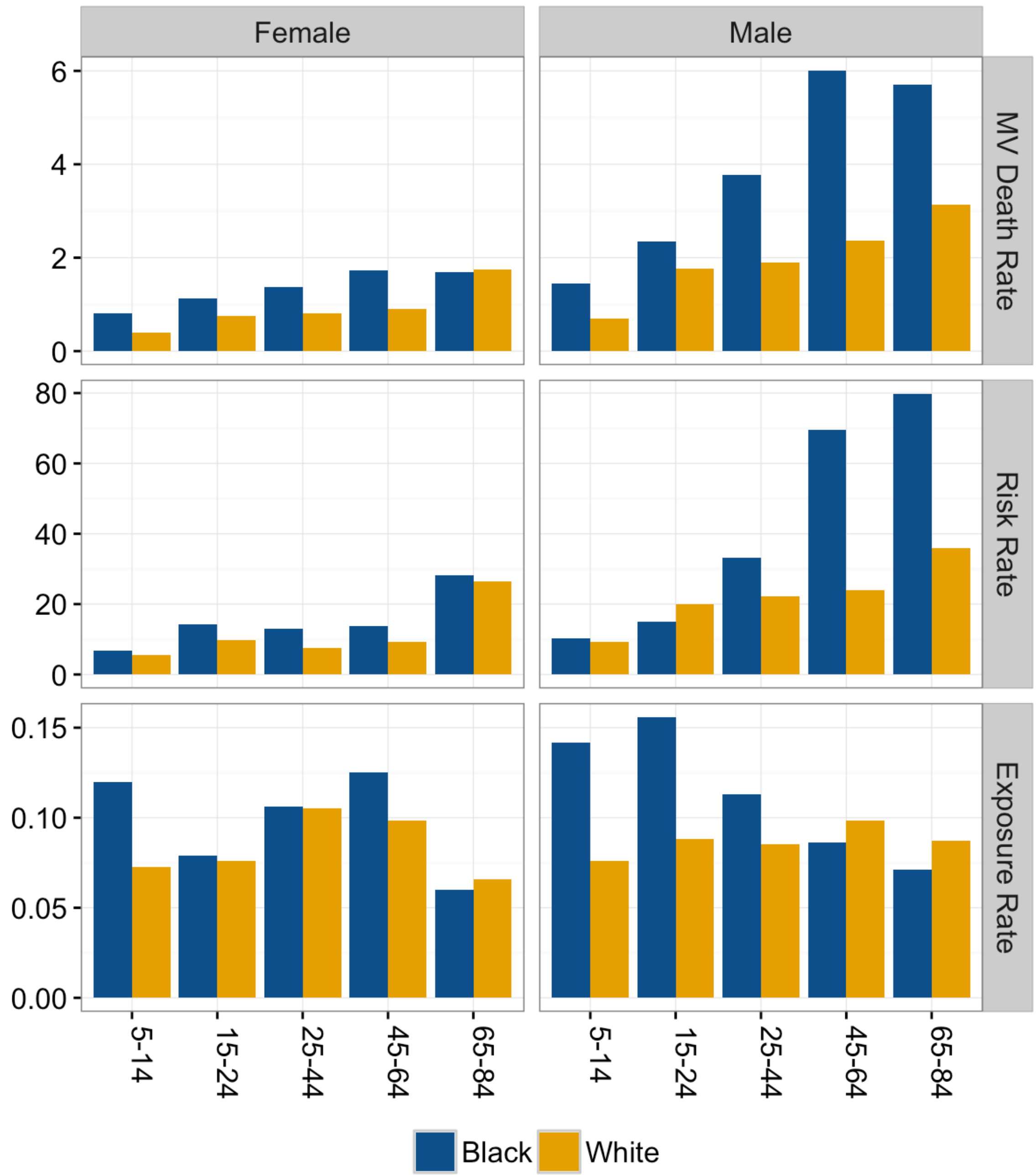
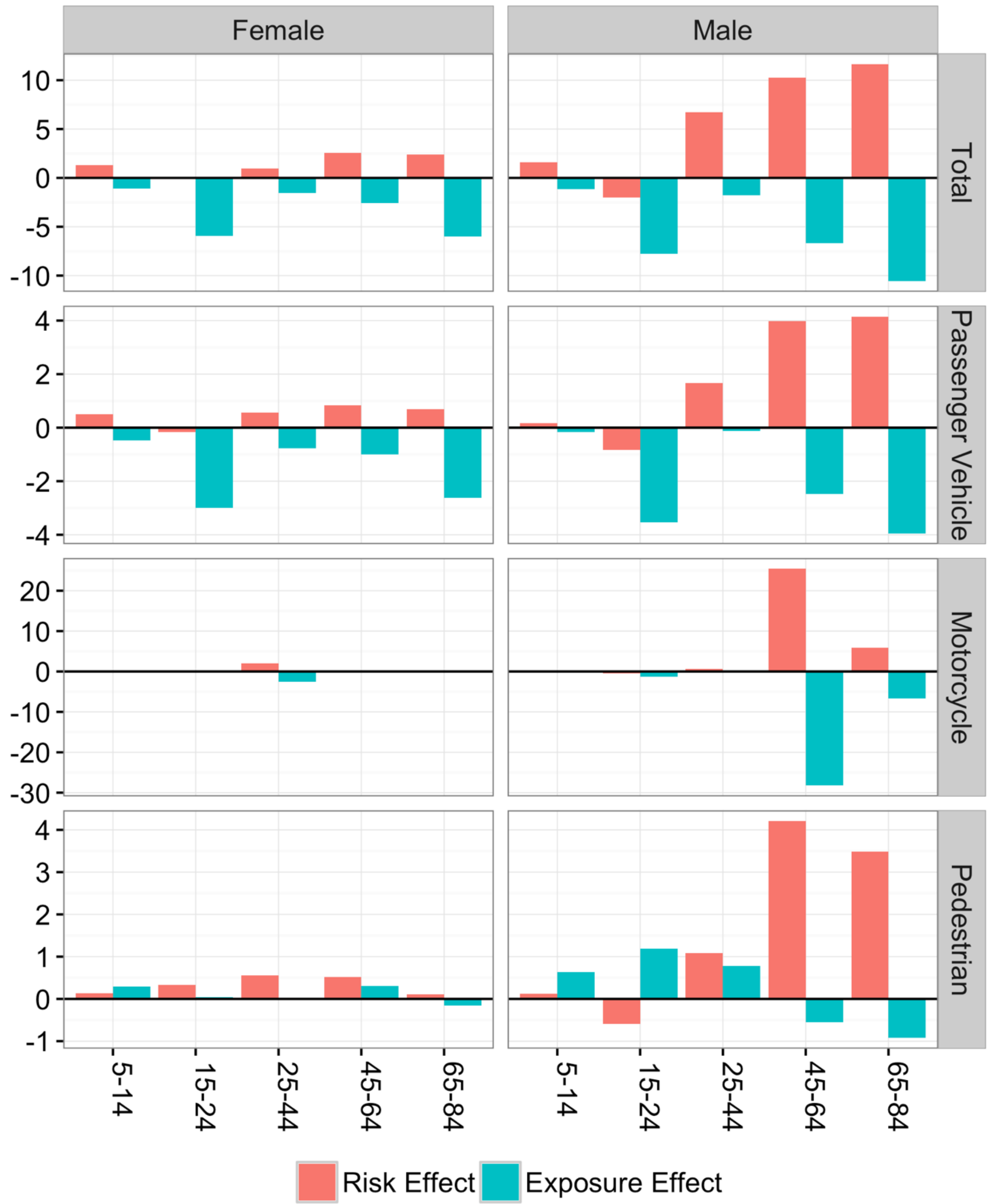


Figure 3.7 Risk and Exposure Effects for Blacks Relative to Whites by Age and Sex for Types of Motor Vehicle Deaths
Note: Y-axis differs



APPENDIX

Appendix 1.1 Definitions and Sources for Control Variables

Variable	Definition	Sources
Beer Tax	State excise beer tax, per gallon, in 2013 dollars	Tax Foundation
Gas Prices	State gas prices include excise tax, per gallon, in 2013 dollars	U.S. Energy Information Administration
Texting Ban	All-driver ban on texting while driving	McCartt, Kidd, and Teoh (2014); Insurance Institute for Highway Safety (IIHS)
Handheld Ban	All-driver ban on handheld cellphone conversations	McCartt, Kidd, and Teoh (2014); Insurance Institute for Highway Safety (IIHS)
BAC Limit	Blood alcohol content (BAC) limit decreases from 0.10 to 0.08	Alcohol Policy Information System
Seat belt law	Primary enforcement of mandatory seat belt laws	IIHS
GDL	Presence of a graduated driver licensing (GDL) program rated as "good" by the IIHS. A good state GDL program is defined as having a mandatory learner's period of at least 6 months and either a night driving restriction from 10PM or allowing no more than one teen passenger until the age of 17. I select the good rating because many states implemented or upgraded their programs to this top rating during the study period.	IIHS; Dee et al. (2005)

Appendix 1.2 Regression Coefficients (SE) for the Relationship between State Unemployment Rate and MV Fatality Rates by Crash Type with Controls, 2003-2013

	Large Trucks	No Large Trucks	Speeding	Non-Speeding	Drunk Driving	Non-Drunk Driving
Unemployment Rate	-0.0837***	-0.0207	-0.0503*	-0.0201	-0.0362**	-0.0254*
	(0.021)	(0.011)	(0.020)	(0.013)	(0.014)	(0.011)
Beer Tax (in 2013 $)	0.1023	-0.0262	-0.0644	0.0182	-0.0460	0.0250
	(0.125)	(0.048)	(0.134)	(0.056)	(0.058)	(0.064)
Gas Prices (in 2013 $)	0.3876*	0.0879	-0.0388	0.2127*	0.0683	0.1280
	(0.170)	(0.069)	(0.208)	(0.088)	(0.134)	(0.075)
Texting Ban	0.0199	0.0150	0.0449	-0.0015	0.0310	0.0269
	(0.047)	(0.021)	(0.065)	(0.029)	(0.034)	(0.024)
Handheld Ban	-0.0182	-0.0363	0.1147	-0.0747	-0.0191	-0.0626
	(0.066)	(0.039)	(0.156)	(0.041)	(0.053)	(0.038)
BAC Limit	-0.0221	-0.0217	0.0362	-0.0566	-0.0161	-0.0212
	(0.096)	(0.057)	(0.100)	(0.045)	(0.060)	(0.053)
Seatbelt Law	0.0268	-0.0118	-0.0433	-0.0017	-0.0412	-0.0024
	(0.052)	(0.026)	(0.051)	(0.032)	(0.037)	(0.027)
GDL	0.0313	0.0167	0.0447	0.0112	0.0273	0.0049
	(0.040)	(0.022)	(0.065)	(0.028)	(0.034)	(0.022)

* p<0.05, ** p<0.01, *** p<0.001

Appendix 1.3 Regression Coefficients (SE) for the Relationship between State Unemployment Rate and MV Fatality Rates by Crash Type with Controls, 2003-2013, continued

	Single-Vehicle	Multi-Vehicle	Rural	Urban
Unemployment Rate	-0.0202	-0.0406*	-0.0174	-0.0457*
	(0.011)	(0.016)	(0.013)	(0.019)
Beer Tax (in 2013 $)	-0.0273	0.0420	-0.0060	0.0730
	(0.048)	(0.085)	(0.067)	(0.095)
Gas Prices (in 2013 $)	-0.0071	0.2744*	0.1450	-0.1070
	(0.076)	(0.123)	(0.143)	(0.162)
Texting Ban	0.0290	0.0069	-0.0007	0.1095
	(0.025)	(0.028)	(0.042)	(0.077)
Handheld Ban	-0.0256	-0.0681	-0.0958	-0.0533
	(0.041)	(0.052)	(0.056)	(0.065)
BAC Limit	-0.0154	-0.0091	0.0476	-0.0944
	(0.061)	(0.044)	(0.068)	(0.083)
Seatbelt Law	-0.0203	0.0004	-0.0229	-0.1096
	(0.032)	(0.027)	(0.049)	(0.062)
GDL	0.0222	0.0068	0.0111	0.0524
	(0.025)	(0.026)	(0.042)	(0.041)

* p<0.05, ** p<0.01, *** p<0.001

REFERENCES

Baker, S.P., O'Neill, B., Ginsburg, M.J., Li, G., 1992. The Injury Fact Book, Second Edition. Oxford University Press, USA.

Baker, S.P., Braver, E.R., Chen, L.-H., Pantula, J.F., Massie, D. 1998. Motor Vehicle Occupant Deaths Among Hispanic and Black Children and Teenagers. Arch. Pediatr. Adolesc. Med. 152, 26–27.

Battelle, 2000. Travel Patterns of People of Color. Prepared for U.S. Department of Transportation, Federal Highway Administration.

Beck, L.F., Dellinger, A.M., O'Neil, M.E., 2007. Motor vehicle crash injury rates by mode of travel, United States: using exposure-based methods to quantify differences. Am. J. Epidemiol. 166, 212–8. doi:10.1093/aje/kwm064

Beck, L.F., Dellinger, A.M., O'Neil, M.E., 2007. Motor vehicle crash injury rates by mode of travel, United States: using exposure-based methods to quantify differences. Am. J. Epidemiol. 166, 212–8. doi:10.1093/aje/kwm064

Blewett , L., Rivera Drew, J.A., Griffin, R., King, M.L., Williams, K.C.W. 2016. *IPUMS Health Survey: National Health Interview Survey, Version 6.2.* Minneapolis: University of Minnesota.

Braver, E.R., 2003. Race, Hispanic origin, and socioeconomic status in relation to motor vehicle occupant death rates and risk factors among adults. Accid. Anal. Prev. 35, 295–309. doi:10.1016/S0001-4575(01)00106-3

Briggs, N.C., Schlundt, D.G., Levine, R.S., Goldzweig, I.A., Stinson, N., Warren, R.C., 2006. Seat Belt Law Enforcement and Racial Disparities in Seat Belt Use. Am. J. Prev. Med. 31, 135–141. doi:10.1016/j.amepre.2006.03.024

Bureau of Labor Statistics., 2015. Labor Force Statistics from the Current Population Survey. Retrieved from http://data.bls.gov/timeseries/LNU04000000?years_option=all_years&periods_option=specific_periods&periods=Annual+Data

Bureau of Labor Statistics., 2017. Employed persons by occupation, race, Hispanic or Latino ethnicity, and sex. Retrieved from https://www.bls.gov/cps/cpsaat10.htm

Burgard, S.A., Ailshire, J.A., Kalousova, L., 2013. The Great Recession and Health: People, Populations, and Disparities. Ann. Am. Acad. Pol. Soc. Sci. 650, 194–213. doi:10.1177/0002716213500212

Campos-Outcalt, D., Bay, C., Dellapena, A., Cota, M.K., 2003. Motor vehicle crash fatalities by race/ethnicity in Arizona, 1990-96. Inj. Prev. 9, 251–6. doi:10.1136/IP.9.3.251

Centers for Disease Control and Prevention, 2013. Motor vehicle traffic-related pedestrian deaths-United States, 2001-2010. MMWR. Morbidity and mortality weekly report, 62(15), 277.

Center for Disease Control and Prevention., 2014. National Vital Statistics System, National Center for Health Statistics. WISQARS Data.

Centers for Disease Control and Prevention., 2016. National Center for Health Statistics. Compressed Mortality File 1968-2015 on CDC WONDER Online Database.

Centers for Disease Control and Prevention., n.d.-a. HIST293: Age-Adjusted Death Rates for Selected Causes by Race and Sex Using Year 2000 Standard Population: Death Registration States, 1900-32 and United States, 1933-49. Retrieved from: https://www.cdc.gov/nchs/data/dvs/hist293_1900_49.pdf

Centers for Disease Control and Prevention., n.d.-b. HIST293: Age-Adjusted Death Rates for Approximately 64 Selected Causes, by Race and Sex: United States, 1950-59. Retrieved from: https://www.cdc.gov/nchs/data/dvs/hist293_1950_59.pdf

Centers for Disease Control and Prevention., n.d.-c. HIST293: Age-Adjusted Death Rates for 60 Selected Causes by Race and Sex using Year 2000 Standard Population: United States, 1960-67. Retrieved from: https://www.cdc.gov/nchs/data/mortab/aadr6067.pdf

Centers for Disease Control and Prevention., n.d.-d. Comparability across revisions for selected causes. Retrieved from: https://www.cdc.gov/nchs/data/dvs/comp2.pdf

Cotti, C., Tefft, N., 2011. Decomposing the Relationship between Macroeconomic Conditions and Fatal Car Crashes during the Great Recession : Alcohol- and Non-Alcohol-Related Accidents. B . E . J. Econ. Anal. Policy 11.

Couch, K.A., Fairlie, R., 2010. Last Hired, First Fired? Black-White Unemployment and the Business Cycle. Demography 27(1): 227-247.

Coughenour, C., Clark, S., Singh, A., Claw, E., Abelar, J., Huebner, J., 2017. Examining racial bias as a potential factor in pedestrian crashes. Accid. Anal. Prev. 98, 96–100. doi:10.1016/j.aap.2016.09.031

Cubbin, C., LeClere, F.B., Smith, G.S., 2000a. Socioeconomic status and injury mortality: individual and neighbourhood determinants. Journal of Epidemiology and Community Health. 54: 517-524.

-----. 2000b. Socioeconomic Status and the Occurrence of Fatal and Nonfatal Injury in the United States. American Journal of Public Health 90: 70-77.

Cutler, D.M., Lleras-Muney, A., 2010. Understanding differences in health behaviors by education. Journal of Health Economics 29(1): 1-28.

Das Gupta, P., 1993. Standardization and decomposition of rates: a user's manual. No. 186. US Department of Commerce, Economics and Statistics Administration, Bureau of the Census.

Davis, R.O., 1975. The Age of Asphalt: The Automobile, the Freeway, and the Condition of Metropolitan America, edited by Harold M. Hyman. J.B. Lippincott Company.

Day, J.C., 1996. Population Projections of the United States by Age, Sex, Race, and Hispanic Origin: 1995 to 2050. U.S. Bureau of the Census, Current Population Reports, P25-1130, U.S. Government Printing Office, Washington, DC. Retrieved from http://www.census.gov/prod/1/pop/p25-1130/p251130.pdf.

Dee, T.S., Grabowski, D.C., Morrisey, M.A., 2005. Graduated driver licensing and teen traffic fatalities. Journal of Health Economics, 24, 571-589.

Denney, J.T., He, M., 2014. The social side of accidental death. Soc. Sci. Res. 43, 92–107.

Farley, R., and Allen, W.R., 1987. The color line and the quality of life in America. Russell Sage Foundation.

Ferdinand, A.O., Menachemi, N., Blackburn, J.L., Sen, B., Nelson, L., and Morrisey, M., 2015. The Impact of Texting Bans on Motor Vehicle Crash--Related Hospitalizations. American Journal of Public Health, 105(5), 859-865.

Franz, K., 2012. “African-Americans Take to the Open Road” in Major Problems in American Popular Culture, edited by K. Fraz and S. Smulyan, pgs 240-253. Wadsworth, Boston, MA.

French, M.T., Gumus, G., 2014. Macroeconomic fluctuations and motorcycle fatalities in the U.S. Soc. Sci. Med. 104, 187–193. doi:10.1016/j.socscimed.2013.12.019

Frijters, P., Johnston, D.W., Lordan, G., Shields, M. a, 2013. Exploring the relationship between macroeconomic conditions and problem drinking as captured by Google searches in the U.S. Soc. Sci. Med. 84, 61–8. doi:10.1016/j.socscimed.2013.01.028

Gerdtham, U., Ruhm, C., 2006. Deaths rise in good economic times: evidence from the OECD. Economics and Human Biology, 4(3), 298-316.

Gibson, C., Jung, K., 2005. Historical Census Statistics On Population Totals By Race For Large Cities And Other Urban Places In The United States. Population Division, Working Paper No. 76. U.S. Census Bureau, Washington, D.C. 20233.

Gove, W.R., 1973. Sex, Marital Status, and Mortality. American Journal of Sociology 79(1): 45-67.

Grabowski, D.C., Morrisey, M.A., 2004. Gasoline Prices and Motor Vehicle Fatalities. Journal of Policy Analysis and Management, 23(3), 575-593.

He, M.M., 2016. Driving through the Great Recession: Why does motor vehicle fatality decrease when the economy slows down? Soc. Sci. Med. 155, 1–11. doi:10.1016/j.socscimed.2016.02.016

Iceland, J., 2017. Race and Ethnicity in America. University of California Press.

Kay, J.H., 1997. Asphalt nation: how the automobile took over America, and how we can take it back. Crown Publishers, Inc.

Kochanek, K.D., Arias, E., and Anderson, R.N., 2013. How did cause of death contribute to racial differences in life expectancy in the United States in 2010? NCHS Data Brief 1–8.

Kochanek, K.D., Murphy, S.L., Xu, J., and Tejada-Vera, B., 2016. Deaths: Final Data for 2014. National Vital Statistics Reports, Volume 65, Number 4.

Laveist, T.A., Wallace, J.M., 2000. Health risk and inequitable distribution of liquor stores in African American neighborhood. Soc. Sci. Med. 51, 613–617. doi:10.1016/S0277-9536(00)00004-6

Lemov, M.R., 2015. Car Safety Wars: One Hundred Years of Technology, Politics, and Death. Fairleigh Dickinson University Press.

Lewis, T. 2013. Divided Highways: Building the Interstate Highway, Transforming American Life. Cornell University Press.

Li, G., Shahpar, C., Grabowski, J.G., Baker, S.P., 2001. Secular trends of motor vehicle mortality in the United States, 1910–1994. Accid. Anal. Prev. 33, 423–432.

Li, G., Baker, S.P., Langlois, J.A., Kelen, G.D., 1998. Are Female Drivers Safer? An Application of the Decomposition Method. Epidemiology 9, 379–384.

Link, B.G., Phelan, J., 1995. Social Conditions As Fundamental Causes of Disease. J. Health Soc. Behav. 35, 80. doi:10.2307/2626958

Liu, C., Chen, C., Subramanian, R., Utter, D., 2005. Analysis of Speeding-Related Fatal Motor Vehicle Crashes. Department of Transportation, Washington, DC. Accessed April 2015.

Lui, M., Dixon, E., Leondar-Wright, B., 2006. Stalling the Dream: Cars, Race and Hurricane Evacuation. United for a Fair Economy's third annual report, State of the Dream 2006.

Lyman, S., Braver, E.R., 2003. Occupant deaths in large truck crashes in the United States: 25 years of experience. Accident Analysis & Prevention, 35(5), 731-739.

McCart, A.T., Kidd, D.G., Teoh, E.R. 2014. Driver cellphone and texting bans in the United States: evidence of effectiveness. Annals of Advances in Automotive Medicine, 58, 99-114.

McKenzie, B., 2015. Who Drives to Work? Commuting by Automobile in the United States, 2013. American Community Survey Reports, ACS-32, U.S. Census Bureau, Washington, DC, 2015.

McKenzie, B., Rapino, M., 2011. Commuting in the United States: 2009. American Community Survey Reports, ACS-15. U.S. Census Bureau, Washington, DC.

Michigan Automobile Insurance Placement Facility. Classifying Commercial Vehicles. Accessed March 2015 from www.maipf.org/guide/vehicles.pdf

Morency, P., Gauvin, L., Plante, C., Fournier, M., Morency, C., 2012. Neighborhood social inequalities in road traffic injuries: the influence of traffic volume and road design. Am. J. Public Health 102, 1112–9. doi:10.2105/AJPH.2011.300528

Morrisey, M.A., Grabowski, D.C., 2011. Gas prices, beer taxes and GDL programmes: effects on auto fatalities among young adults in the US. Applied Economics, 43(25), 3645-3654.

National Bureau of Economic Research. US Business Cycle Expansions and Contractions. Accessed October 2014 from http://www.nber.org/cycles.html

Neumayer, E., 2004. Recessions lower (some) mortality rates: evidence from Germany. Soc. Sci. Med. 58, 1037–1047. doi:10.1016/S0277-9536(03)00276-4

NHTSA., 2009. 2008 Traffic Safety Annual Assessment - Highlights. Department of Transportation, Washington, DC. Accessed December 2015. http://www-nrd.nhtsa.dot.gov/Pubs/811172.pdf

-----., 2010. Highlights of 2009 Motor Vehicle Crashes. Department of Transportation, Washington, DC. Accessed December 2015. http://www-nrd.nhtsa.dot.gov/Pubs/811363.pdf

-----., 2013. 2012 Motor Vehicle Crashes: Overview. Department of Transportation, Washington, DC. Accessed April 2015. http://www-nrd.nhtsa.dot.gov/Pubs/811856.pdf

Olsen, E.M., Shults, R.A., Eaton, D.K., 2013. Texting While Driving and Other Risky Motor Vehicle Behaviors Among US High School Students. Pediatrics. 131(6): 1708-1715.

Pampel, F.C., 2001. Gender Equality and the Sex Differential in Mortality from Accidents in High Income Nations. Popul. Res. Policy Rev. 20, 397–421.

Pew Research Center. 2015. Multiracial in America: Proud, Diverse and Growing in Numbers. Washington, D.C.

Pucher, J., Evans, T.M., Wenger, J., 1998. Socioeconomics of Urban Travel: Evidence from the 1995 NPTS. Transp. Q. 52.

Raley, R.K., Sweeney, M.M., Wondra, D., 2015. The Growing Racial and Ethnic Divide in U.S. Marriage Patterns. Future Child. 25(2): 89-109.

Randill, A., Greenhalgh, H., Samson, E., 1973. Nationwide Personal Transportation Study: Mode of Transportation and Personal Characteristics of Tripmakers. Report No. 9. U.S. Department of Transportation, Federal Highway Administration. Retrieved from: https://www.fhwa.dot.gov/ohim/1969/v.pdf

Ruhm, C., 1995. Economic conditions and alcohol problems. Journal of Health Economics, 14(5), 583-603.

-----., 2000. Are Recessions Good for Your Health? The Quarterly Journal of Economics, 115(2), 617-650.

-----., 2003. Good times make you sick. Journal of Health Economics, 22(4), 637-658.

-----., 2015. Recessions, healthy no more? Journal of Health Economics, 42(C), 17-28.

Santos, A., McGuckin, N., Nakamoto, H.Y., Gray, D., Liss, S., 2011. Summary of Travel Trends: 2009 National Household Travel Survey. Washington, DC.

Seiler, C., 2012. "'So That We as a Race Might Have Something Authentic to Travel By': African-American Automobility and Cold-War Liberalism". In Slethaug, G.E., Ford, F. *Hit the Road, Jack: Essays on the Culture of the American Road*. McGill-Queen's Press.

Silver, D., Macinko, J., Bae, J.Y., Jimenez, G., Paul, M., 2013. Variation in U.S. traffic safety policy environments and motor vehicle fatalities 1980-2010. Public Health 127, 1117–1125. doi:10.1016/j.puhe.2013.10.003

StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP.

Subramanian, R., 2002. Transitioning to Multiple Imputation – A New Methods to Impute Missing Blood Alcohol Concentration (BAC) values in FARS. NHTSA, Washington, DC.

Tapia Granados, J.A., 2008. Macroeconomic Fluctuations and Mortality in Postwar Japan. Demography 45, 323–343.

Umberson, D., 1987. Family status and health behaviors: Social control as a dimension of social integration. Journal of Health and Social Behavior 28(3): 306-319.

U.S. Department of Transportation, Federal Highway Administration. 2011. 2009 National Household Travel Survey: User's Guide. Retrieved from: http://nhts.ornl.gov/2009/pub/UsersGuideV2.pdf

U.S. Federal Highway Administration, 1976. Social and Economic Effects of Highways. U.S. Department of Transportation, Federal Highway Administration, Office of Program and Policy Planning, Socio-Economic Studies Division.

Wagenaar, A.C., 1984. Effects of macroeconomic conditions on the incidence of motor vehicle accidents. Accident Analysis & Prevention, 16(3), 191-205.

Wagenaar, A.C., Streff, F.M., 1989. Macroeconomic conditions and alcohol-impaired driving. Journal of Studies on Alcohol, 50(3), 217-25.

West, B.A. Naumann, R.B., 2011. Motor Vehicle–Related Deaths—United States, 2003–2007. CDC Health Disparities and Inequalities Report—United States, 60, p.52.

Xu, X., 2013. The business cycle and health behaviors. Soc. Sci. Med. 77, 126–36. doi:10.1016/j.socscimed.2012.11.016

Zhu, M., Zhao, S., Coben, J.H., Smith, G.S., 2013. Why more male pedestrians die in vehicle-pedestrian collisions than female pedestrians: a decompositional analysis. Inj. Prev. 19, 227–231. doi:10.1136/injuryprev-2012-040594